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Vol 15 DIAGNOSIS 1974
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WATER SOLUBLE CONTRAST MEDIA AND ADHESIVE ARACHNOIDITIS

II Reinvestigation of operated cases

L. IRSTAM and M. ROSENCRANTZ

Adhesive arachnoiditis after lumbar myelography with Pantopaque has been described as rare (e g HARVEY & FREIBERGER 1965) although extensive reactions have been reported (DAVIES 1956 FISHER 1965 SHAPIRO 1968 and others) The condition has also occasionally been reported after lumbar myelography with various water soluble contrast media a causal relationship between the medium and the arachnoiditis has sometimes been obvious but sometimes only possible

AUTIO et coll (1972) described adhesive arachnoiditis at repeat myelography of 6 patients primarily examined with methylglucamine iothalamate (Conray 60) but no reaction in 12 patients primarily examined with methiodal (Kontrast U) None of the patients had been operated upon between the first and second myelographies The lesions were not verified pathologically in 5 of the 6 patients with radiologic changes suggesting adhesive arachnoiditis The sixth patient died later from a malignant disease At autopsy the spine was removed en bloc despite careful dissection no changes could be demonstrated in the meninges and microscopy failed to reveal any signs of arachnoiditis (AUTIO 1972)

From the Department of Diagnostic Radiology II (Director Prof I Wickbom) Sahlgrenska sjukhuset 413 45 Gothenburg Sweden Submitted for publication 29 December 19 2

Tabl 1

Frequency of adhesive arachnoiditis

Contrast medium at first examination	Patients operated upon after first examination			Patients not operated upon after first examination		
	Total	With adhesive arachnoiditis		Total	With adhesive arachnoiditis	
Kontrast U	50	39	78	32	10	31
Conray 60	3	1	33	3	0	0
Dimer X	12	5	42	7	0	0

The frequency of adhesive arachnoiditis following myelography with various water-soluble contrast media was the subject of a recent article (IRSTAM & ROSENCRANTZ 1973): the patients had not been operated upon before repeat myelography.

It is known that adhesive arachnoiditis may occur in patients who have been operated upon before a myelography. The changes may be so severe as to be difficult to distinguish from those due to herniation of a vertebral disc. The myelograms of patients who had been operated upon before repeat myelography have been reviewed in order further to elucidate their pathogenesis.

Material and Methods. The primary material is identical to that described in part I. It consisted of 856 patients primarily examined with Kontrast U (Group I), 152 primarily with Conray 60 (Group II), and 500 patients primarily with Dimer X (Group III). Fifty patients of Group I, 3 of Group II and 12 of Group III were operated upon shortly after the first examination and were re-examined after a varying interval. There were 14 patients in Group I and 2 in Group III who were also examined a third time; of these latter 16 patients 6 were reoperated upon after the second myelographic examination. Kontrast U having been used also for the second examination in 5 patients and Dimer X in one patient (Table 6). Two further re-examined patients from Group I were excluded since the films were missing.

The myelographic technique has been described in detail previously (IRSTAM et coll. 1970, IRSTAM & ROSENCRANTZ 1973). The patients were first examined lying on the affected side, then prone and finally on the opposite side. The amounts of medium used were: 10 to 12 ml Kontrast U, 5 ml Conray 60 mixed with 2 to 4 ml of CSF, or 4 to 5 ml of Dimer X mixed with an equal volume of CSF.

Tabl 2

Changes in caudal root pockets

Contrast medium at first examination	Patients operated upon after first examination with adhesive arachnoiditis		Patients not operated upon after first examination with adhesive arachnoiditis	
Kontrast U	37	74	10	51
Conray 60	1	33	0	0
Dimer X	5	42	0	0

The interpretation was mainly the same as in part 1 The following changes were thus recorded

(A) Impaired filling of root pockets graded as follows Grade 1 — Incomplete filling on one side, normal on the other Grade 2 — Incomplete filling on both sides Grade 3 — No filling on one side normal on the other Grade 4 — No filling on one side, incomplete on the other Grade 5 — No filling on either side

(B) Abnormalities in the appearances of the cul de sac its position in the spinal canal as well as of the visibility of nerve roots in the caudal part of the subarachnoid space

(C) Root pocket cysts the extent to which they were filled, and their appearances

In addition to these criteria the post-operative deformation had to be interpreted and—if possible—a distinction made between these changes and those caused by adhesive arachnoiditis

Results

The frequency with which myelographic changes of adhesive arachnoiditis appeared between first myelography and repeat myelography appears in Tables 1 to 5

Root pockets Changes were evident in the root pocket of S3 in 37 patients of S2 in 37 of S1 in 28 and of L5 in 15 patients in that part of the material primarily examined with the Kontrast U technique The various types and the distribution of the changes are presented in Table 3

Rep at myelography disclosed root pocket changes in 1 patient in that part of the material examined with Conray 60 grade 5 changes were present at the level of S3 and S2 while at the level of S1 the change was grade 3

Table 1

[illegible]

Contrast medium (in first examination)	Total	W[illegible]	[illegible]	Total	With [illegible]	[illegible]
Kontrast U	?0	3?	8	3	10	1
Conray 60	3	1	33	3	0	
Dimer X	1		4		0	

The frequency of adhesive arachnoiditis following myelography with various water soluble contrast media was the subject of a recent article (IRSTAM & ROSENCRANTZ 1973); the patients had not been operated upon before repeat myelography.

It is known that adhesive arachnoiditis may occur in patients who have been operated upon before a myelography. The changes may be so severe as to be difficult to distinguish from those due to herniation of a vertebral disc. The myelograms of patients who had been operated upon before repeat myelography have been reviewed in order further to elucidate their pathogenesis.

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Table 3

[illegible]

Severity	R[illegible]			
	S3	S[illegible]	S1	L5
Grade 1	3	8		1
Grade 2	0	0	3	
Grade 3	1	14	10	8
Grade 4	3	4	5	3
Grade 5	1[illegible]	11	3	1

Repeat myelographs revealed root pocket changes in 5 patient[illegible] in that part of the material examined with Dimer X and afterward[illegible] operated upon[illegible] in one of these grade 5 changes were present at the level of S3 and S2[illegible] in another case there were grade [illegible] changes at the level of S3 and grade 4 changes at S[illegible]. In the third patient grade [illegible] changes were evident at the level of S3 and S2[illegible] while in the fourth patient the changes were of grade 1 and situated at the lev[illegible] of S3[illegible] S2[illegible] S1 and L5. The fifth patient is described below.

Cul de sac. The cul-de-sac was deformed equally often in all 3 groups (Table 4)[illegible] its evaluation in the Conray and Dimer X techniques mu[illegible]t be made with caution because the materials were so[illegible] small.

All the patients in the Kontrast U and Conray 60 materials with deformation of the cul-de-sac also had coexisting changes of the root pockets and redu[illegible]ed definition of the nerve roots in the caudal part of the subarachnoid space. The cul-de sac in the Dimer X material was deformed in 5 patient[illegible] including 4 [illegible]ith involvement of several root pockets. Repeat myelographs in the fifth patient revealed that the caudal part of the subarachnoid [illegible]pace was much narro[illegible]er than at the primary examination. The nerve roots and root pockets on one [illegible]de had ordinary appearances. On the other side[illegible] where the patient had been operated upon in the meantime for herniation of a vertebral disc at the level of L5—S1[illegible] a postoperative deformation was present. Repeat myelographs produ[illegible]ed normal filling of the root pockets of L5 and S1[illegible] while that of S2 was defecti[illegible]e as in adhesive arachnoiditis.

Table 4

Changes in the cul-de-sac

Contrast medium at first examination	Patients operated upon after first examination with adhesive arachnoiditis		Patients not operated upon after first examination with adhesive arachnoiditis	
Kontrast U	1	4	3	
Conray 60	1	33	0	0
Dimer X		4	0	0

Table 5

Changes in root pocket cysts

Contrast medium at first examination	Patients operated upon after first examination with adhesive arachnoiditis		Patients not operated upon after first examination with adhesive arachnoiditis	
Kontrast U	10	50	2 6	33
Conray 60	0 0	0	0	0
Dimer X	1 4		0 1	0

Irrespective of the type of contrast medium used for the preoperative myelography, in all patients in whom the root pockets had been only partly filled or not filled at all at repeat myelography the corresponding nerve roots were less distinctly outlined. When two or more consecutive root pockets were involved the impaired definition of the nerve roots varied with the extent of the process in the root pockets. When changes occurred bilaterally in the entire cul-de-sac no nerve roots could be identified in that part of the subarachnoid space. As previously reported (IRSTAM & ROSENCRANTZ) patients who were subjected to repeat myelography without having undergone any operation in the meantime had changes extending around the nerves in the subarachnoid space adjacent to the origin of the root pockets. In all patients in whom no adhesive arachnoiditis was demonstrable the definition of the roots was normal at both examinations.

Root pocket cysts. Root pocket cysts were demonstrated at primary myelography of 10 patients examined with Kontrast U; in 3 of these the cysts were bilateral and in 2 of these 3 patients no filling of the root pocket cysts was obtained at repeat myelography. In the first of these latter 2 patients no filling was obtained either of the root pockets of S3 and S2 or of one of the root pockets of S1 while the filling of the other S1 pocket was less than at the primary

Tabl 6

Patient examined by myel raphy m e than t ic F g es on the left half f th table den t th fn g at the fir t effe t myel g aph and to the ght han on th same patient at the second repeat mye graphy

Proce l j lied t the p em my lgr g hy	N f p tient	P t pt w th han die	P oce l re j lg l the p my l gr p l	P t t w l l l l	P tients w th acerat l acl f fter first repe t my l gr p l
K p	4	J	K p K	4	
K p		l	K p C		0
K p		1	Kop D		1
D p		l	D p D	l	1
K p	4	4	K p K p	4	4
K p	1	l	K p D p	1	0
K j p	l	1	K j j K p	l	l

K lumt my l gr p l perf ed w h K t L
C l l m l gr p l y perf l w h C or t 0
D l mt n l gr p l perf rm l w t D N
p perat f d sc lernia perf rm l af g l ng my l gr pl
pera f l sc lerni t af er p ce l ng l gr pl

my lography The pocket of one of the root of L5 situated on the side on which the root pocket of S1 remained unfilled was only partly filled at repeat myelography while the opposite L5 root pocket appeared normal the cul-de sac also appeared normal In the second patient root pocket cysts were pr sent adjacent to the root pockets of S3 at the primary examination However these cysts could not be demonstrated at rep at myelography which revealed a defective filling of the root pocket of S3 on one side and no filling at all of the corresponding root pocket on the other side the cul de sac appeared normal

Filling of a cyst adjacent to one of the root pockets of S2 or S3 was obtained at primary myelography in 3 patients These root pockets were at most partly filled at repeat myelography and the corresponding root pocket cy t were unfilled

No filling was obtained of root pocket cysts at any of the examinations in the Conray 60 material

Root pocket cysts were present at the primary lumbar myelography in 4 patients in the Dimer X material including 1 with bilateral changes only in that patient no filling at all was obtained of root pocket cysts at the second myelography At the same time the filling of the pockets of S3 and S2 roots was defective and the cul-de sac was deformed this was strikingly narrow and hour glass in shape In addition to these patients in whom the absence of filling of

Table 7

Postoperative deformation of the subarachnoid space

Contrast medium at first examination	No of patients examined	No of patients with deformation
Kontrast U	50	20 (40)
Conray 60	3	2 (67)
Dimer X	12	3 (25)

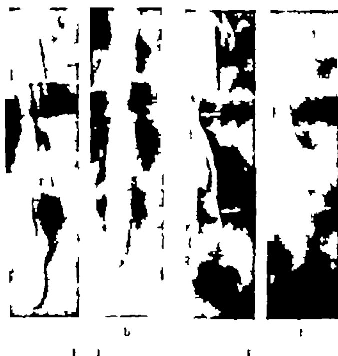
the root pocket cysts at repeat myelography was readily recognized from other changes suggesting extensive adhesive arachnoiditis, 2 patients had a somewhat paradoxical filling of root pocket cysts These 2 patients had primarily been examined with Kontrast U had been operated upon for herniation of a vertebral disc and had afterwards been re-examined with Dimer X because of recurrent symptoms Filling was obtained at the primary examination of a cyst of one of the root pockets of S3 in one of these patients no further root pocket cyst could be demonstrated The second examination indicated filling of the same cyst at the level of the root pocket of S3 although the filling of the pocket itself was poor Outlining was also obtained of cysts of the contralateral root pockets of S1 S2 and S3 at the second myelography in spite of the fact that the root pocket of S3 on that side was only partly filled

Primary myelography in the second patient had revealed filling of a root pocket cyst at the level of one of the S3 root pockets but no further root pocket cyst could be demonstrated No filling was obtained of the root pockets of S3 and S2 on that side at repeat myelography The cul de sac was narrow and hour glass in shape while the nerve roots in the cul-de sac could not be identified The root pocket cyst filled at primary myelography was not outlined at the second myelography but filling was obtained of a root pocket cyst in connection with the contralateral S2 and S3 root pockets in spite of the fact that the root pocket of S2 was just partly filled the S3 pocket not at all

The primary examination was technically satisfactory in these cases the contrast concentration was acceptable and judging from the good definition of minor details in the myelogram filling of any of the root cysts would have been recognised

Discussion

None of the pat ur previous series (IRSTAM & ROSENCRANTZ 1973) of repeat myelogr hout operation had signs of primary arachnoiditis at the first examin



F 1 Ope [illegible] for hernia [illegible] S1 Repea [illegible] def rma [illegible] Further o era [illegible] R [illegible] this level F [illegible] [illegible]

Fig Disc herniat L4 L5 → A small [illegible] pocket of the S1 root → Opera [illegible] the level [illegible] same disc and extend [illegible] 0.5 cm below [illegible] of S1, S2 and S3 [illegible] filled Neither [illegible] cul-de-sac [illegible] could be identified Further [illegible] revealed recurrent herniat[illegible] and extradural adhesions

The patients in the present material who were operated upon once and in two instances twice between the first and the second myelographies included one patient with extensive changes suggesting adhesive arachnoiditis in the cul-de-sac at the primary examination. The root pockets of S3 and S2 were obliterated bilaterally and both root pockets of S1 and L5 were only partly filled. The patient had had lumbago-sciatica for 6 months. The spinal canal had not been operated upon before the first myelographic examination, neither had any lumbar puncture been performed. Furthermore the myelography suggested herniation of the disc between L5 and S1 and was confirmed at later operation. The pain abated after the operation but positive neurologic signs were still demonstrable. Repeat myelography indicated a recurrence of the



b

Fig 3



b

Fig 4

Fig 3) Disc herniation t L5—S1 Verified t operation b) Tw years later repeat myelography indicated herniation t L4—L5 The cul d sac was shorter than in) root pockets below the herniation ill defined Operation t level of L4—L5 revealed bulging disc but no true herniation the disc was incised but no sequestrum was evident) Three years later 2 cm long defect abov t and below L4—L5 Th cul-de sac was completely obliterated t the middle of L5 and no nerv roots could be identified below L4—L5 Further operation revealed herniation but no extradural adhesions the level belo w L4—L5 was not explored

Fig 4) Primary myelography Operation revealed herniation t L4—L5 b) Repeat myelography revealed total and irregular obliteration of the cul de sa t L4—L5 the nerv roots just above the bloc poorly outlined Further operation revealed extradural adhesions and a mild adhesiv arachnoiditis but no di herniation (Case 2)

herniation as well as a new deformation of the most caudal part of the cul de sac The root pockets and the rest of the subarachnoid space were unchanged The recurrent hernia was operated upon and the patient afterwards felt ll and had no neurologic signs Judging from th e two series primary adhe arach noiditis is rare and can seldom play a role in the cause of change ppearing at repeat myelography

The interval between the first and th econd examination w th Kontrast U

was 6 to 110 months (average 17 months). This interval was much longer than that in our former series in which it was 15 months. The interval between the first and the second examination of the 3 patients who were examined first with Conray 60 ranged from 10 to 19 months (average 15 months). In the unoperated material, in which none of the patients examined first with Conray 60 had adhesive arachnoiditis, the corresponding mean interval was 11 months. The interval between the examination was 8 months (range 2 to 10 months) in those patients examined and re-examined with Dimer X. The corresponding figures were 16 months and 10 to 23 months in the unoperated material.

No statistically significant correlation was evident in the present operated material as in the unoperated material between the frequency, spread and severity of the adhesive arachnoiditis and the interval between the examinations. The material would not permit any conclusions as to the time necessary for adhesive arachnoiditis to develop after myelography. The interval between the examination was fairly long and never less than two months.

It is clear from the accompanying tables that the frequency of adhesive arachnoiditis was notably higher when the patients had been operated upon between the two examinations. This finding should, however, be interpreted with caution. It should be borne in mind that at least as far as Kontrast U is concerned the interval for the unoperated patients was much shorter than for those who had been operated upon in the meantime. This, however, is of less importance because no correlation was evident between the interval between the examinations and the occurrence of adhesive arachnoiditis. In the two different materials the interval between the two examinations in the Kontrast U group on one hand and the Conray 60 and Dimer X groups on the other was very different.

In the evaluation of the differences in frequency and severity it should be remembered that the Conray 60 and the Dimer X series were small. The frequency of adhesive arachnoiditis after lumbar myelography with Kontrast U was 31 per cent in the unoperated material and 78 per cent in the operated material, i.e. a difference of 47 per cent. The corresponding differences in the Conray 60 and the Dimer X groups were 33 and 42 per cent respectively. The main difference between the unoperated re-examined group and the operated re-examined group was the operation per se. It appears reasonable to assume that operation causes adhesive arachnoiditis of varying severity with a frequency of about 30 to 40 per cent.

Repeat myelography in 35 of the patients in the present material revealed disc herniation in a different localization compared to the first herniation. The frequency of arachnoiditis among these 35 patients did not differ significantly from that in the rest of the material irrespective of the type of contrast medium

used at the first examination Neither was any significant difference found in the frequency of arachnoiditis between the patients in the group with herniation of a vertebral disc and the remainder The changes observed decreased in frequency in a cranial direction, irrespective of medium administered If absence of filling of root pockets be regarded as the greater change and partial filling as a less severe one, it would mean that the lesions decreased in severity in a cranial direction Although asymmetric these changes were always more marked on the affected side i e where the concentration of medium had been the highest

Even though the material primarily examined with Conray 60 or with Dimer X and afterwards operated upon was small the extent and degree of the changes in the root pockets were the same as those after myelography with Kontrast U and subsequent operation The results are also in full agreement with those that occurred in the previous material in which repeat myelography was performed without preceeding operation

The changes were relatively small in the 6 patients with deformation of the cul de sac after lumbar myelography with Conray 60 or Dimer X and subsequent operation Several of the 21 patients with deformation of the cul de sac after myelography with Kontrast U likewise presented mild deformation In this part of the material there were also a few patients with advanced deformation of the subarachnoid space It is possible that these cases of marked adhesive arachnoiditis occurred only in the larger series owing to statistical variation There is however reason to infer that the advanced deformation of the most declive part of the subarachnoid space was more common after lumbar myelography with Kontrast U than following myelography performed with any of the other contrast media used

It was always noted how far down the spinal canal the subarachnoid space was demonstrable Neither the presence nor the severity of adhesive arachnoiditis varied with the extent to which the cul de sac extended down the spinal canal irrespective of the type of medium used at the first examination

It is not known why the filling of root pocket cysts and occasionally the filling of the root pockets in the cul de sac as well varied from the first to the second examination It is possible that sometimes the adhesive arachnoiditis was due to loose fibrous strands in the subarachnoid space A root pocket and that part of the subarachnoid space just before its origin might be partly shut off from the normal circulation of the CSF Owing to possible openings and passages between the fibrous strands it is possible that a small amount of contrast medium might have passed out into a root pocket cyst without filling the corresponding pocket

Once it had been realised that adhesive arachnoiditis is so common all the reports of the first operation were carefully examined The operator had nearly

always noted whether any substantial extradural bleeding or not had occurred. No correlation was proved between the presence of extradural bleeding and the occurrence of adhesive arachnoiditis. The surgeon had recorded that at three operations he had accidentally made a small slit in the dura: in none of these patients was adhesive arachnoiditis observed at repeat myelography. The frequency of arachnoiditis did not vary with the operator; neither was any difference recorded in frequency or severity of arachnoiditis between patients surgically explored at one or more levels on one or both sides. The surgeon's report of the second operation in the re-operated cases were also analysed: it was usually stated whether extradural adhesions had been present or not. There was no correlation between the presence or absence of extradural adhesions and the existence or severity of adhesive arachnoiditis myelographically demonstrated.

The findings at operation after the first myelographic examination in 15 of the 65 patients was herniation of a disc. Of these, three were free sequestra which in 2 patients were displaced laterally in the spinal canal and in 1 patient caudally. The affected disc in 7 patients was not herniated but protruded. The operation findings in 6 patients varied, e.g. vertebral exostoses bulging into the subarachnoid space, oedematous nerve root with surrounding extradural scar formation. Exploration had revealed no pathologic findings in another 4 patients.

Irrespective of the findings at myelography listed, postoperative scar formation often occurred (Table 7). The deformation of the subarachnoid space extended both above as well as below the disc explored. The opinion of CRONQVIST (1959) that postoperative deformation only at the level of the disc indicates a recurrence of a herniation while scar tissue has a tendency to produce deformation extending somewhat above and below the disc explored was fully appreciated in the retrospective evaluation of the films. CRONQVIST's postulation could however not be confirmed in spite of the fact that the results of further operation were known.

The observation by LINDGREN (1951, 1954) that the myelographic change produced by recurrent herniation of a disc is often situated further ventrally than a postoperative deformation was sometimes verified, but such a finding is by no means the rule: most patients who really had recurrent herniation of a disc also presented postoperative deformation in the ventral part of the subarachnoid space. It would therefore appear that it is usually not possible myelographically to distinguish between postoperative deformation and recurrence of disc herniation. These extradural changes that complicate the interpretation of postoperative myelograms must be added to those caused by adhesive arachnoiditis. As pointed out, these changes may be marked, partly or completely obstructing the subarachnoid space and thereby simulate recurrent herniation of the disc or postoperative deformation by extradural scar formation.

With the examination technique used the expansion of the cul de sac appears so vary somewhat with the extent to which the headend of the examination couch is raised This should be borne in mind in the evaluation of deformation if any of this part of the subarachnoid space Isolated deformation of the cul de sac without simultaneous root pocket changes and decreased visibility of nerve roots has however never been encountered Autio was unable to demon strate adhesive arachnoiditis in the one case in which autopsy was performed The dura was surgically opened for direct inspection in 2 of the present cases

Case 1 Woman aged 52 in whom the first myelographi examination performed with Kontrast U revealed typical changes f left-sided herniation of the L4—L5 disc This was confirmed t operation at which the corresponding area on the right side was also explored with negativ results Owing t recurrent symptoms the patient again underwent operation 41 months later at the same level and w thout repeat lumbar my lography Massive extradural adhesion as well as two small herniation residues were present on the l ft sid Complete laminectomy f L5 and partial laminectomy of L4 were performed

The patient had recurrent symptoms and was re examined with Kontrast U tw years later i e 65 months after the first myelographic examination The cul de sa which at the first examination extended down to the level f the lower margin of S1 was now filled with contrast medium t the lower margin of L5 and was caudally rounded with somewhat irregular outline No nerv roots could be identified below the middle of L5 nd no root pockets demonstrated at or below this ertebra The dura t further operation had eviden of adhesiv arachnoiditis biopsy of the adhesion evealed cicatrised sclerosed connectiv tissue with some small vessels particles f blood pigment and infiltrates of round cells i e scar tissue

Case 2 Woman aged 48 The first lumbar myelography with Kontrast U revealed changes suggesting herniation f the disc at L4—L5 but no other abnormality The caudal end f the subarachnoid space was demonstrable down to th upper marg f S1 Bilateral surgical exploration at th level of the possible herniation of the disc revealed nothing of interest The dura was opened and the filum terminal was found t be much thickened Since no other changes that could explain th severe coccygod nia wer present the roots were partly divided by diathermy The condition f th patient failed to improv and 14 months later myelography by the same method was epeated This time the sub-arachnoid space proved to be completely obstructed at the level of the upper margin of L5 Surgical exploration disclosed a small extradural cyst hich was interpreted as meningocel spurium No herniation was evident The dura was re-opened and extensiv ara hno ditis particularly caudally was now present Biopsy indicated chronic inflammation (Fig 4)

The changes described were evidently of the same nature whether operat n had been performed or not and were due to adhesive arachnoiditis There o appeared to be no doubt that the changes following myelography alor ere due to the chemical or toxic effects of the contrast medium and p bly the spinal anaesthetic The distribution and the severity of these change sed with the local concentration of the medium in the subarachnoid space T e exposure time which was longer when larger volumes of contrast medium were u ed

might also have been of importance. This assumption is supported by the report of AHLGREN (1972) of a much higher frequency of adhesive arachnoiditis in patients examined with Conray 60 or Dimer X and in whom the volumes of contrast medium used were larger than in the present material.

The mechanism for the changes due to surgery must be explained in some other way since the dura is usually not opened during the operation. The most probable explanation seems to be circulatory changes secondary to bleeding or to thrombosis of small vessels. This mechanism may also contribute to the changes following myelography, at least if the puncture is complicated by bleeding. Lesions of this kind may also enhance the irritating effect of the contrast medium, a supposition supported by the high frequency of changes in repeat myelography following operation (Table 6).

SUMMARY

The present investigation suggests that lumbar myelography with methiodal (Kontrast U) after preceding spinal anaesthesia is more likely to produce adhesive arachnoiditis than myelography with methylglucamine iothalamate (Conray 60) or its dimer (Dimer X). Furthermore it appears that operation per se for herniation of the affected disc involves a definite risk of adhesive arachnoiditis irrespective of the type of contrast medium used in the prior myelography.

ZUSAMMENFASSUNG

Die vorliegende Untersuchung deutet darauf hin, dass die Lumbalmyelographie mit Methiodal (Kontrast U) nach vorangehender Spinalanästhesie mit grösserer Wahrscheinlichkeit eine adhäsive Arachnoiditis hervorruft als die Myelographie mit Methylglucamin iothalamat (Conray 60) oder dessen Dimer (Dimer X). Ausserdem scheint eine Operation per se wegen der Herniebildung des betroffenen Discus ein klares Risiko für eine adhäsive Arachnoiditis unabhängig vom Typus des bei der vorhergehenden Myelographie verwendeten Kontrastmittels mit sich zu bringen.

RÉSUMÉ

Ce travail de recherche fait penser que la saccoradiculographie lombaire avec le méthiodal (Kontrast U) après rachianesthésie doit probablement entraîner plus souvent une arachnoïdite adhésive que la saccoradiculographie avec le méthylglucaminiothalamat (Conray 60) ou son dimère (Dimer X). De plus il semble que l'opération en elle même pour hernie discale atteint comporte un risque certain d'arachnoïdite adhésive quel que soit le type de moyen de contraste utilisé dans la saccoradiculographie préalable.

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POSTOPERATIVE PSEUDODIVERTICULA (SPURIOUS MENINGOCELES) OF THE CERVICAL SUBARACHNOID SPACE

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Gas myelography is in our opinion the best method to determine the level of cord involvement and extent of adjacent bone or soft tissue alteration before surgical procedures in order to ameliorate cervical myelopathy due to spondylosis. It also provides an excellent means of assessing the post-operative status of the cord and subarachnoid space. By means of this procedure we have been able to demonstrate pseudodiverticula of the cervical subarachnoid space in nine patients out of twenty one following surgery.

Materials and Methods. Gas myelography was performed both pre- and post-operatively in twenty-one patients with cervical spondylosis and myelopathy. The technique used was similar to that described by ROTH (1963) and LEKSELL & RÅDBERG (1967) employing a single lumbar subarachnoid puncture with removal of approximately 40 ml of cerebrospinal fluid before injection of a corresponding amount of humidified oxygen. Tomography was accomplished

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a b

Fig 1 Lateral gas myelograms from t\ cases one month follo\ ing laminectomy and dentat section) Large air filled sac extending into the cer\ ical soft tissues for the length of lmost f\ cer\ ical ertebrae b) Small pseudodi erticulum ppears continuous \ th the posterior subarach noid space opposite C7

utilizing the hypocycloidal trajectory of the Polytome Surgery in all instances consisted of posterior laminectomy and dentate ligament section In nine cases out pouchings of the posterior cervical subarachnoid space were demonstrated approximately one month post operatively These structures were variable in size ranging from one cm in diameter to 4 cm × 9 cm in transverse and axial dimensions and occasionally protruded for some distance into the soft tissues of the neck (Figs 1a 2) Six of the patients had uneventful post-operative courses The remaining three however developed unexpected clinical symptoms and signs which consisted of low grad fevers ranging from 20 to 40 days in duration unattended by any apparent source of infection, and posturally induced syncope and headache The latter were particularly marked when arising from the supine position and unassociated with any alteration in blood pressure The following case is illustrative

Case Report

A 38 year-old man was admitted f llowing fall coincident ith sudden loss f sensation in his right leg and hand He denied any symptoms before the incident Neurologic examination revealed weakness f the right biceps triceps and intrinsic muscles f th right hand Right upper and lower extremity reflexes were spastic and unsustained nkl clonus and a positive Hoffmann sign were present Hyperactiv reflexes wer present on the left and hyperesthesia long the sixth cervical dermatom was noted N intracranial abnormalities were found

Gas myelography revealed narrow cervical canal aggravated by soft ti sue thickening at the level of th third rvical interspace Laminectomy from C3 through C6 was performed combined ith dentat ligament section This was f llowed by definit improv



[illegible] three [illegible] artery [illegible] length of th[illegible] The [illegible] of the lateral [illegible]

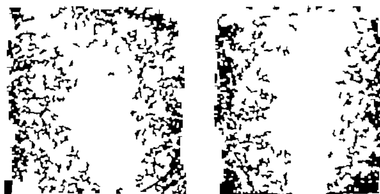


Fig. 5. Scan performed 30 minutes following subarachnoid instillation of RISA and technetium albumin [illegible]) Later [illegible] b) [illegible] (Cf. with Fig. 9 b)

ment in th neurologic signs but the post-operativ course wa compl cated by fever po turall induced headache and occasional syncope

A repeat gas myelography one month follow ing surgery demonstrated 5 cm × 6 cm × 8 cm gas filled sac continuous with and extend n from the subarachnoid spa e int the po terior cervical soft tissues (Fig 2 a b) In order t further document the commun ca tion nd to provide base line for later examinations 2 mCi of technetium lbumin combined with 100 μCi of RISA were introduced int the lumbar subarachno d space Scans of the cervical area (F g 3) were taken at 30 minutes 24 and 48 l ours The isotope activity was highest at 30 minutes and gr dually faded on the later scans

The symptoms gradually subsided d ring the second po t-operativ month and th sa had completely disappeared when h was re exam ned 3 months f llowing surgery (Fig 2) Repeat isotope scanning at this time also failed to demonst ate the les on

Discussion

The occurrence of cyst like communications with the subarachnoid space fol owing lumbar laminectomy has been described by others and variously de ignated as post-operative meningoceles meningeal pseudocysts or spurious meningoceles WINKLER & POWERS (1950) BOROSTROM (1954) KETTLER (1956) and RENALDI & PEACH (1969) have suggested that these structures are true meningoceles and either the result of herniation of arachnoid membrane or consequent arachnoid proliferation through a rent in the dura In a ca e reported by PAONI et coll (1961) however there was no evidence of arachnoid herniation A tear in both the subarachnoid and dura provided the route for egre s of cerebrospinal fluid into para vertebral planes Connective tissue response subsequently provided a lining for the pseudocystic cavity Further h sto ogic evidence that this occurs was provided by MILLER & ELDER (1968) who presented ten cases with similar lesions

Whereas it is entirely possible that true meningoceles may occur incident to dural perforation we have chosen to regard the nine cases in our eries as false or spurious meningoceles The apparent total disappearance of these structures in three patients within three to six months following surgery suggests that continuing inflammatory reaction may either produce fibrosis and shrinkage of the existing sac or that local tis ue proliferation at the communicating point may produce closure followed by eventual resorption of cerebrospinal fluid

SUMMARY

Nine cases f pseudodi r la of the cervical subarachnoid space following l minectomy and dentat section are ...sed Three patients within the group developed unexpected symptoms post operat umed elated t the pseudodiverticula Complet disappear ance f th structures d hin si months of the operativ procedure

ZUSAMMENFASSUNG

Neun Fälle eines Pseudodivertikels des zervikalen Subarachnoidalraums im Anschluss an Laminektomie und Dens-Sektion werden beschrieben. Drei Patienten dieser Gruppe entwickelten unerwartet postoperative Symptome, die vermutlich mit den Pseudodivertikeln im Zusammenhang stehen. In allen Fällen verschwanden dieser Strukturen innerhalb von sechs Monaten nach der Operation.

RÉSUMÉ

Description de neuf cas de pseudodiverticule de l'espace sous-arachnoïdien cervical après laminectomie et section du ligament dentelé. Dans ce groupe, trois malades ont présenté des symptomes post-opératoires inattendus, vraisemblablement en relation avec les pseudodiverticules. On a observé la disparition des pseudodiverticules dans les six mois qui ont suivi l'intervention.

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EQUI-OSMOLAL OPENING OF THE BLOOD BRAIN BARRIER IN THE RABBIT BY DIFFERENT CONTRAST MEDIA

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Neurotoxicity of contrast media used in carotid angiography may follow opening of the blood brain barrier (BBB) and entry of the media into the brain parenchyma (ROSENTHALL et coll 1969 LAMPE et coll 1970 ALMEN 1971) Severity of the barrier disturbance is related to the concentration of the contrast medium and the period of time in which it acts on the cerebral vessels Although severity can differ from one contrast medium to another this difference is thought to depend on specific effects of the medium on blood viscosity or on endothelium of the vessels and to be related mainly to the ionic and chemical content of the medium

Of the many factors that may contribute to BBB damage however solution osmolality is considered relatively unimportant (HARRINGTON et coll 1966 ALMEN 1971) For example BROMAN & OLSSON (1949) and BASSETT et coll (1953) concluded that thresholds for BBB damage by different agents were independent of solution osmolality [illegible] they compared the effects of glucose NaCl Diodrast, Dijodon [illegible] Umb[illegible]

Submitted for publication 20 Febr[illegible] 19[illegible]

Table

Comp[illegible] of contrast media [illegible] and [illegible] perfusion volume [illegible] and [illegible] osmolalities

Medium	Anion	Cation	Molarity	Volume fraction	Corresponding osmolality
Ang[illegible]	[illegible]	[illegible]	1	0.17	0.40
				0	1.8
Con[illegible]	[illegible]	Methyl		0.33	0.49
		gluc[illegible]		0.17	0
				1.0	1.43
Hypaque [illegible]	Dia[illegible]	Na	0.8	0.33	0.49
				0.17	0.9[illegible]
				1.0	1.[illegible]7
[illegible]grafin [illegible]	Diat	N[illegible]	0.1	0.[illegible]	0.37
		Methyl		0.41	0.[illegible]
		gl		0.17	1.30
[illegible]paque [illegible]	Metriz[illegible]	Ca	0.01	0.5	0.93
		N[illegible]	0.1[illegible]	0.17	1
				0.83	1.[illegible]0
				1.0	1.8
[illegible]paque 2[illegible]0	Metriz	C[illegible]	0.01	0.33	0.4[illegible]
		Methyl		0.17	0.9[illegible]
		glucami		0.9	1.4
NaCl	Chloride	N[illegible]		3 g/100 ml	0.91
				4 g/100 [illegible]	1.[illegible]
				5 g/100 ml	1.38

Osmolality calculated by extrapolat[illegible]

The cerebral blood vessels constitute a barrier to exchange of ions and large molecules between brain and blood because they do not have pores between the endothelial cells but only tight junctions (REESE & KARNOVSKY 1967; KARNOVSKY 1968). Physiologic evidence suggests and morphologic evidence confirms that concentrated solutions of electrolytes and relatively lipid insoluble nonelectrolytes such as urea open the BBB reversibly by separating the tight junctions that connect the endothelial cells (RAPOPORT 1970, 1971, 1973 a; RAPOPORT et coll. 1972, 1973; BRIGHTMAN et coll., unpublished). The tight junctions probably open when the endothelial cells shrink.

Contrast media in clinical use are as concentrated as solutions that have been shown to open the BBB osmotically. These media may therefore open the tight *junctions between cerebrovascular endothelial cells as does urea, for example.* Such a mechanism would be likely if the media were shown to open the BBB at the same threshold osmolality, independently of their chemical or ionic nature.

It therefore was of interest to reexamine the conclusions of ALMÉN (1971) BROMAN & OLSSON (1949) and BASSETT et coll (1953) We determined thresholds for BBB opening by 6 contrast media which differed in chemical composition, and compared the thresholds to those of NaCl and other agents

Methods

Ninety four rabbits weighing 1 5 to 2 5 kg were anesthetized with ethyl carbamate (urethan) (1 6 g/kg i p) In the last 60 animal blood pressure was recorded with a strain gauge transducer through a femoral artery catheter The left external and common carotid arteries were exposed and ligated and the left common carotid was catheterized cephalic to the ligation for brain perfusion (STEINWALL 1958) The skull was trephined and the dura removed over a small region of the left hemisphere in order to observe pial vasculature during perfusion

Five minutes before perfusion 4 ml/kg of 2 g Evans blue/100 ml 0 9 % NaCl (Chroma Gesellschaft Schmid and Company Stuttgart) was injected into a catheterized femoral vein This quantity of dye is bound completely to blood albumin (FREEDMAN & JOHNSON 1969 RAPOPORT et coll 1972) Five to 12 ml of test solution was perfused manually for 30 to 40 seconds into the left internal carotid via the common carotid at a pressure which expelled the blood from the pial arterioles of the exposed brain surface Different concentrations of 6 contrast media and of NaCl were perfused each concentration being tested in 4 to 6 animals

The animal was killed 30 to 45 minutes after carotid perfusion The chest was opened the right atrium cut and 200 ml of 0 9 % NaCl followed by 400 ml of 10 % formaldehyde solution was perfused through the left ventricl when the descending aorta was clamped The brain then was removed and observed and photographed for staining and distribution of extravasated Evans blue dye both on the surface and after sectioning Kodachrome slides were examined later without knowing which agent was perfused and barrier damage was classified in four groups as follow (0) No observable extravasation of dye (+) light extravasation in local region usually at the left temporal lobe (++) light and diffuse extravasation over greater part of left hemispherical cortex (+++) diffuse dye extravasation over left hemisphere with superimposed dark blue regions

Occasionally dye xtravasated in the right rather then left hem phere po sibly because of v in vascular architecture or reactivity (JEPPSSON & OLIN 1970) We did istinguish between left and right sided damage in our classification

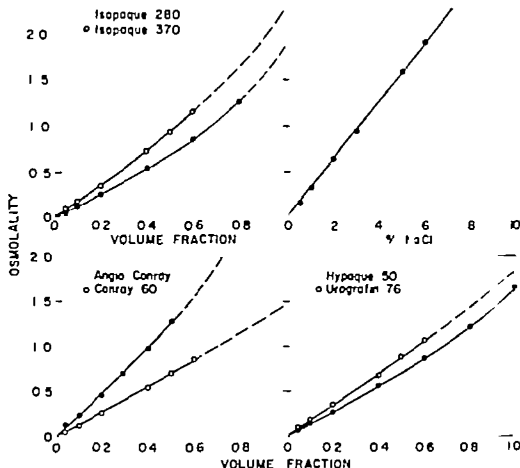


Fig 1 Relation of solution osmolality to volume fraction of contrast medium and to percent NaCl (g/100 ml) The abscissa is $V_m/(V_m + V_w)$ where V volume and subscript m denotes the medium w denotes water The points are experimentally determined osmolalities Osmolalities of high volume fractions and of undiluted media are not given because either freezing did not occur at the normal supercool temperature or measurements were not reproducible Dashed lines represent extrapolated osmolalities in these regions

Solutions The 6 contrast media used are listed in the Table together with their generic names and salt contents when available They had 3 different anions and different cation contents Angio-Conray and Conray 60 are manufactured by Mallinckrodt Chemical Works (St Louis, Missouri) Urografin 76 by Schering A G (Berlin West Germany) Hypaque 50 Isopaque 370 and Isopaque 280 by Sterling Winthrop (New York, N Y) Conray 60 Hypaque 50 Urografin 76 and Isopaque 280 are used for carotid angiography while Angio Conray and Isopaque 370 are not

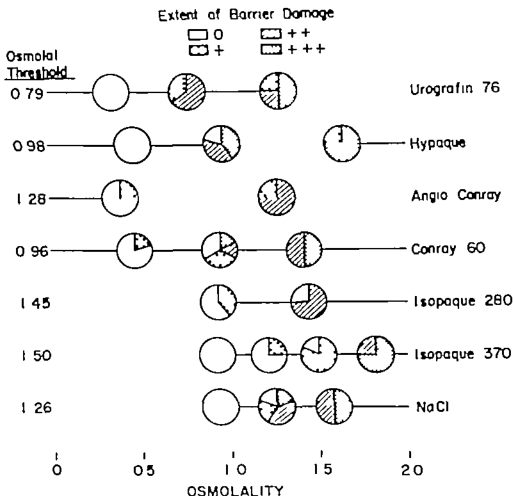


Fig 2 Blood brain barrier damage at different osmolalities of 6 contrast media and NaCl Barrier effects of different osmolalities of a given agent are presented on a horizontal line The center of a circle denotes the osmolality of the solution which was tested by internal carotid perfusion Each circle is divided proportionately to the fraction of animals in which a given grade of barrier breakdown was produced

Solutions of given volume fractions of contrast media (Table) were injected into the internal carotid artery to test barrier opening (Volume fraction = $V_m/(V_m + V_w)$ where V = volume m denotes medium and w water) Threshold and extent of damage were examined for each solution and related to solution osmolality Threshold for BBB opening is defined as the lowest test osmolality which produced some damage (+ to +++) in at least 50 per cent of the animals

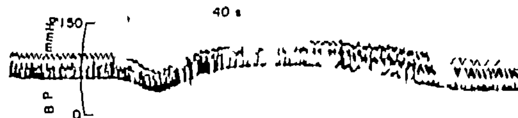


Fig. 3. Blood pressure [illegible] 0.8 osmolal Urografin [illegible]

Osmolalities were measured by freezing point depression with a Precision Systems Osmometer (Natick, Massachusetts) and were related to volume fractions of the media (Fig. 1). For undiluted or slightly diluted media freezing either did not take place at the normal supercool point or measurements were not reproducible, possibly because solute and solvent separated out simultaneously (BORDALEN et al. 1970). For more dilute solutions osmolality was roughly linear with volume fraction. Osmolalities of the concentrated solutions were estimated by extrapolation, and agreed with osmolalities as found by Hill's method to within about 10 per cent (BORDALEN et al.; NICKEL, personal communication). Osmolalities corresponding to given volume fractions are listed in the Table.

Results

Fig. 2 presents observations on barrier breakdown by the 6 contrast media and NaCl. Barrier opening at different osmolalities of each medium are presented on a single horizontal line. The center of a circle denotes the osmolality of the solution which was tested; the corresponding volume fraction can be found from Fig. 1 or the Table.

Each circle is divided proportionately to the fraction of animals in which a given grade of barrier breakdown was produced. For instance, 1.3 osmolal Urografin 76 produced +++ damage in 1/2 of the animals tested, ++ damage in 1/4 and + damage in 1/4. Four to 6 animals were tested at any given osmolality of an agent.

The proportion of animals in which ++ and +++ damage were produced increased with increasing osmolality for each agent. Threshold, or the lowest osmolality which produced + to +++ damage in at least 50 per cent of the animals tested, is given on the left hand side of each horizontal line. The mean threshold for the 6 contrast media is 1.16 ± 0.27 SD osmolal, and does not differ significantly ($p > 0.05$) from the NaCl threshold of 1.26 osmolal.

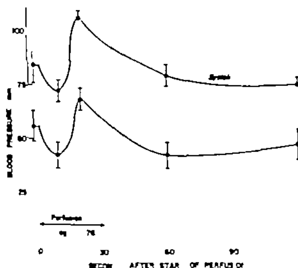


Fig 4 Mean blood pressure changes following internal carotid perfusion of 0 8 osmolal and 1 3 osmolal sol tions of Urografin 76 The baseline lues re means ±SD for 7 imals The points t 9 and 20 econds represent mean maxima and minima in syst lic and diastolic pressures while those t 1 and minutes are mean pressure lues The corresponding SD are calculated from differences w thi each animal between observed and baseline (zero time) pressures

The range of thresholds in Fig 2 encompasses those of the media of the Diodrast group tested by BROMAN & OLSSON (1949) and BASSETT et coll (1953) Umbradil Forte (Diethanolamine salt of 3 5-diiodo-4 pyridone N acetic acid + Diethylamine) was shown to break down the BBB under similar exp rimental conditions at 1 3 osmolal Dijodon 35 % (Diethanolamine salt of diiodo-pyridone N acetid acid) opened the barrier at 0 8 osmolal and Diodrast 35 % (Diethanolamine salt of 3,5 diiodo-4 pyridone N acetic acid) did o at 1 0 osmolal (cf RAPOPORT 1973 a)

Cardiovascular effects The contrast media may affect profoundly the cardiovascular system (ALMEN 1971) TORNELL (1968) used the hypotension and bradycardia produced by internal carotid perfusion as an index of neurotoxicity but HILAL (1966) and JEPPSSON & OLIN (1970) concluded that convulsions and blood brain barrier damage were ind pendent of cardiovascular effects

We also found that perfusion of contrast media and NaCl usually produced an *initial fall in blood pressure which reached a minimum 10 second after the* start of perfusion follo ed by a secondary rise in pressure that reach d a maximum at about 20 seconds and laste l for the duration of p rfusion B ady cardia usually was associa ed with the pressure changes

Fig 3 is an exampl t e blood pr response to Urografin 76 ; rfusion but without bradycar nd Fig 4 marizes the responses in / animals to 0 8 and 1 3 osmolal Ur fin 76 lutic At 1 and 2 minutes after perfusion starts blood pressure t to close to its i itial value

The hypertensive responses to media injected at threshold and at the next higher osmolality (Fig. 2) are ranged as follows for 4 agents adequately examined: NaCl = Isopaque 370 > Urografin 76 > Conray 60. Conray 60 did not give a statistically significant hypertensive response. Neither the hypertensive nor hypotensive response to perfusion was correlated with threshold for BBB breakdown (cf. Fig. 2).

Discussion

In view of the many factors that could affect retention and delivery of contrast media to the cerebral vessels, it is not surprising that the range of threshold osmolalities for barrier breakdown is between 0.8 and 1.5 osmolal, with a SD of 0.26, and that the grade of barrier opening at threshold is variable (Fig. 2). The end point of Evans blue staining, moreover, is a gross indicator of BBB opening and probably occurs at higher osmolalities than necessary for smaller tracers (RAPOPORT 1973 a).

The close grouping of the thresholds of the 6 contrast media in the Table suggests that they act in the main as a function of number of solute molecules or their osmolality, and that their *different chemical and electrolyte compositions* modify but do not determine strongly the threshold for BBB breakdown. The thresholds of the three media previously tested—Umbradil Forte, Dijodon and Diodrast—and of NaCl belong to the same population as do the thresholds in Fig. 2, further supporting the hypothesis that the media as a whole act on the barrier at approximately the same osmolality.

Osmotic opening of the blood brain barrier should depend on solution osmolality and be independent of chemical specificity, and should be reversible (RAPOPORT 1971, 1973 a). The approximately equi-osmolal thresholds of the 6 contrast media and of NaCl support the suggestion that they open the barrier osmotically. Furthermore, the reversible opening by the media and by NaCl also agrees with the osmotic hypothesis (BROMAN & OLSSON 1948, FLODMARK & STEINWALL 1963, STREICHER et coll. 1964, RAPOPORT et coll. 1972).

The tight junctions between the cerebrovascular endothelial cells are opened by the osmotic action of urea and probably of other concentrated solutions (RAPOPORT et coll. 1972, 1973). On the basis of the equi-osmolal actions of the contrast media on the BBB, we suggest that these agents also open the barrier by opening the tight junctions, probably by shrinking endothelial cells. This suggestion must be tested by electron microscopy.

More investigations should be done also on the time course of reversibility as a function of concentration, chemical composition and perfusion time. In the rabbit, the barrier closes within 30 minutes after being opened by 2 molar urea and following Diodrast 35 % perfusion it closes within 2 hours (RAPOPORT

1973 a BROMAN & OLSSON 1948) EEG changes following brain entry of contrast media may last longer than 2 hours because of slow excretion from the brain extracellular space (FLODMARK & STEINWALL 1963 CSERR 1971)

Knowing reversibility time is important for the clinic because neurologic sequelae follow more often the second rather than the first perfusion of a contrast medium when the second is given within 15 minutes of the first (HILAL 1966) Although convulsions are not produced by hypertonic NaCl solution alone an initial hypertonic NaCl perfusion increases the incidence of convulsions to later perfusion of contrast media, suggesting that the hypertonic NaCl has opened the barrier (HILAL 1970)

Osmolality *appears to be a major regulator of the extent and distribution* of BBB breakdown, but the chemical nature of the contrast medium may play a part The anions of contrast media have specific effects on P uptake by brain and on microcirculation and Na Ca and meglumine contents also may affect BBB opening (GONSETTE & ANDRE BALISAUX 1969 MARGOLIS & YERASIMIDES 1966 ALMEN 1971) From the present data and those of JEPPSSON & OLIN (1970) and HILAL (1966) experimental barrier opening does not appear to be affected strongly by the systemic cardiovascular responses to intracarotid perfusion unless marked hypotension is produced

Barrier opening and neurotoxicity are not equivalent Media with high Na content do not open the barrier at lower osmolalities than media with the corresponding anions but lower Na (Fig 2) although the latter are less neurotoxic clinically (HILAL 1970 ALMEN 1971)

Permanent ligation of the common carotid artery in the monkey performed usually in investigating the effect of agents on the barrier using internal carotid perfusion (STEINWALL 1958) will produce often ischemic necrosis of the perfused hemisphere (RAPOPORT et coll 1972) However osmotic barrier opening by 2 molar urea or lactamide can be produced without apparent long term neuronal damage if perfusion is through the lingual artery and if the common and external carotid arteries are clamped only for the period of perfusion (RAPOPORT 1973 b RAPOPORT & THOMPSON 1973)

Neurotoxicity therefore is related to the specific effect of the medium on neuronal function once it enters the brain When the barrier is intact, entry into the brain of drugs and electrolytes that exist in dissociated (ionic) and associated forms is regulated mainly by the concentration of the associated form at blood pH, and by the pH d[illegible]ce between blood and cerebrospinal fluid RALL et coll 1959) The [illegible]oluble contrast media are mainly di[illegible]ociated at physiologic pH The [illegible] iatrizoate metrizoate iothalamate and iodopyracet range from 3 1 to 3 [illegible] methanol water (NICKEL personal communication)

Even if almost ompletely dissociated however organic electrolytes will cros the blood brain barrier if they have ignificant lipid solubility a hown for long chain monocarboxylic acids OLDENDORF 1971 Analy is of the chemical tructure of the organic anions of the contra t media uggest that th y too will cro the BBB to a ignificant degree and that differences in clinical neurotoxicity are related to differences in lipid solubility RAPOPORT & LEVITAN 1973 A much a 1 5 per cent of the pla ma level of contrast agents i f und in the cerebr pinal fluid 1 hour after intravenous infusion MCCLENNAN & BECKER 1971

Acknowledgements

W thank Drs Giovanni Di Chir E gene Streicher nd S d k K H lal f the r l ful comment Dr Arno Brunnemann f Schering AG and M A R Sack l f Sterl — Winthrop Rese r h Ins tut er kind en u h to pr id mples f co trast med and leva t inform tion bout them

SUMMARY

S contrast media f differing mpo ion hen perf ed t the internal tid rtery of rabbits for 30 seconds opened the blood brain barrier t mea osmot thr hold of 1 16±0 27 SD osmol l n t d fferent from th 1 2 hreshold osmolality for NaC The pproximat l equi-o molal threshold for barrier opening by th media nd N Cl est that the contrast media open the tight j ncti ns between cerebrov cular endothelial lls probabl by osmoticall shrinking th lls them elv

ZUSAMMENFASSUNG

Sechs Kontrastmittel erschiedener Zusammensetzung die 30 Sekunden lang d Arteria arotis interna on Ratten inf ndiert wurden ffneten die Bl t Gehirn Schrank bei einer mittleren osmotischen Schw ll on 1 16±0 2 S D o molal d sich nicht der 1 26 Schw llenosmolalitat fur NaCl unterschied Die etw aqui-osmolalen Schw llen ert f die Öffnung der Schrank durch die Kontrastmitt l und N Cl la en erm ten dass die Kontrastmedia den dichten Zusammenhalt zwischen den cerebrovask laren Endothelzellen w hrscheinlich durch eine osmoti he Schrumpfung der Z llen selbst ffnen

RÉSUMÉ

Six moyens d contrast d composition different perfuses dans l artère carotid interne d lapins pendant 30 secondes ont ouvert la barrier hemato-encephaliqu à un seu l osmotiqu moyen d 1 16±0 27 D.S o molaire ne different pas d seuil osmolaire de 1 26 pour le N Cl Les seuils pproximativement equi-osmolaires pour l ouverture de cett barriere par les moyens de contrast et par le N Cl font pen er qu les moyens d contrast ouvrent les jonctions etanches entre les cellules endothéliales cerebro asculaires probabl ment par retraction osmotique des llules lles memes

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OBSERVATION OF THE CERVICAL SEGMENT OF THE SPINAL CANAL BY AN EXTENSION DEVICE

Akos Kovacs

The cord is suspended elastically in the spinal canal so that the effect of movement is considerably decreased. There are two components of any movement: one being the result of traction of the cord while the spine is bowed, and the other its inherent displacement composed again of two types, viz. one being the result of transmitted arterial pulsation and the other changes in the pressure of the fluid (Kuhlendahl 1970). Thickening or calcification of the dura may inhibit these movements by interfering with the blood supply of the cord; this is dependent on the integrity of branches of the anterior spinal artery which enters the cord through septum-like structures between the arachnoidea and dura. The dura mater of the spine consists of internal and external laminae separated from each other below the epistropheus by a space filled with a venous plexus, lymphatic vessels and adipose tissue.

The posterior longitudinal ligament that extends along the spinal canal is loosely attached to the external lamina of the dura; on the other hand, the latter firmly adheres to the wall of the intervertebral foramina. According to Rau (1972), thickening of the dura, arachnoid adhesions and cysts frequently occur with chronic mechanic irritation. Smaller or larger calcified areas are often

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Fig. 1. Thickening of the longitudinal posterior ligament and narrowing of the vertebral canal. Lesion of the spinal cord

observed in the dura at laminectomy. GAIZLER (1971), however, surveyed 200 healthy young individuals at roentgen examination and failed to detect calcification in the posterior longitudinal ligament. BOIJSEN (1954) and later RAU (1972) pointed to the relatively great variability in the sagittal diameter of the spinal canal (12 to 14 mm). The cervical segment of the cord lying in a relatively narrow part of the spinal canal is easily exposed to mechanical irritation from thickening of the dura or ligaments and from disc protrusions (Fig. 1).

Examination of the posterior margins of the vertebrae seems thus to be important; unfortunately, conventional lateral roentgenograms of the cervical spine are not suitable for this purpose, as the articular processes mask this area. Two variations are encountered in the cervical spinal column. If a lower vertebra is anteposed, the upper end of the articular process hides the postero-inferior edge of the vertebra above it (Fig. 3); if an upper vertebra is anteposed, the process of the lower vertebra does not interfere with this part of the upper vertebra (Fig. 2).

Apart from normal anatomic variations three further possibilities contribute to the difficulties in depicting the posterior edge of the vertebrae in the film.

Congenital malformation (deformed articular process). The articular surfaces of the adjacent vertebrae form two parallel oblique planes. The block enclosed by these planes has normally a rhomboid appearance in a lateral view. The upper articular surface may, however, have a more oblique, almost vertical position. The block then loses its rhomboid appearance and approaches the form of a triangle. The upper vertebra consequently will slip along the articular surface of the upper process posteriorly and downward and the posterior lower edge of

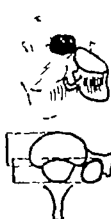


Fig 2

Fig 2 The deformed articular process and its projection in relation to the vertebral body

Fig 3 The upper end of the articular process without and with traction (top and middle) The triangular block obscures the posteroinferior edge of the upper vertebra

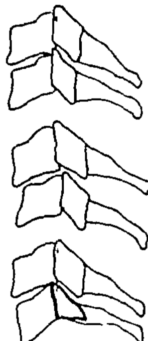


Fig 3

the vertebra will be obscured in the film (Fig 2) If there are several such deformed blocks the shape of the whole spinal column will be altered the cervical lordosis, eventually also the dorsal kyphosis being augmented

Increased lordosis without such deformity

Arthrosis of the small joints The broadened protruding a u uar u ra and osteophytes cover the posteroinferior edge of t vertebra

In uncomplicated cases the functional roentgenogram in ant flexi r re mended by Junghanns (1952) i usually satisfactory for the cl a d ect r t the posterior portion of the cervical vertebra and the anterior wall of th p canal while in other cases the addition of extension to anteflexion may be t

Anteflexion and traction t e same time may be performed with ple stand a rotating disc pr ided with a belt for f xation of the head and a ushion for the chin and forehead The patient pushes his fixed head forwards by means of the two handles (Fig 4) until he feels that further traction would cause pain By allowing the arms and shoulders to hang the transverse dimension of the lower cervical part becomes narrower Extension for a few minutes causes the

Fig

Fig 5b

Fig 4

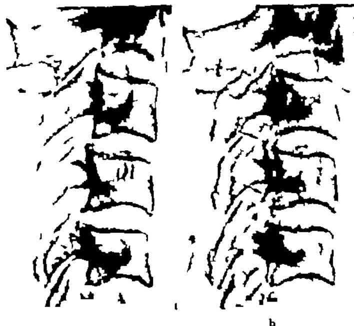
Fig 5 S [illegible] nt fl [illegible] nd tract

Fig Post [illegible] f ertebra [illegible] tl out nd th [illegible] re pectiv l

vertebrae to move lowly apart Fig 5 b If care be taken that the central ray be parallel to the frontal plane the right and left articular processes will be projected upon each other and no bony part will cause masking By this procedure c al ified ligament and cartilage protruding into the pinal canal m y be demonstrated if they ontain at least some deposited calcium Roentgenograms taken after this procedure will produce a clear representation of the post rior edge of the vertebrae *The films of the neck will be rich in detail with the* flexibl cassette of Schinz Sagittal tomograms were also obtained in all po itive cases For obviou rea ons the pre ence of an odontoid bone or aplasia of the dens have to be excluded before application of this traction technique

HENSSOE (1957 has demonstrat d in healthy curarized and anaesthetized individuals that C2 to C6 are considerably displaced from each other during traction for several minutes and the articular surface of the small joints enclose a space that is 1 to 2 mm broader than without traction The women of the Asian Padoung people extend their neck to 30 to 50 cm by a piral device made of copper a procedure that is started at the age of 10 to 12 years When the child becomes adult her vertebrae have roamed from each other by s veral centimeters *This abnormal extension or the wire coil producing this effect seem* to cause no untoward symptoms

It is ab olutely necessary to carry out the proposed procedure with almost geometric accuracy If for example the sagittal plane of the patient is not



b

Fig 6 Calcified ligament not visible on a) straight lateral view but on b) slightly oblique view



Fig 7 Case 1 Ligament calcification behind a fractured vertebra



Fig 8 Case Calcified longitudinal ligament



Fig 9 Case 3 Ligament calcifications between C3 and C5



F 1 C 1 Ligame
1 1 between
3 C

parallel with the film projection distortion may occur. Thus the cortical contour of the uncinate process may reach the edge of the vertebra lying above it and may be confused with a calcified longitudinal ligament. A calcified ligament is, however, not invariably demonstrated even with this technique, for if the calcified part of the ligament lies in a corresponding concavity of the spinal column it can be depicted only by turning the neck by 10 to 15° (Fig. 6) or by tomography.

It is often impossible in patients with short and relatively stiff necks to reveal the posterior contour of the disc or the vertebrael edge. Nevertheless the method described may also prove useful since comparison of the conventional films taken with and without extension may yield important information. Structures in the area of the spinal canal may consist of the posterior edge of the vertebra, the longitudinal ligament or the dura, or circumscribed sclerosis of the articular process. If, however, such structure moves upwards with the upper vertebra in extension the conclusion has to be drawn that it does not represent a calcified ligament or cartilage but belongs to the bony structures of the upper vertebra.

Calcification of the posterior longitudinal ligament of the spine. It is common knowledge that under certain circumstances mechanical or chemical irritation may result in local calcification of tissues. Deposition of calcium is particularly common in periarticular tissues often followed by complete ankylosis. This reaction obviously constitutes protection of abnormally weak joint cartilage or intervertebral disc by restricting the movements. Radiographic examination of traumatized limbs often reveals calcification of the soft tissues near the joints. POLCAR (1929) in referring to the ossification of the spinal ligaments distinguished calcification of the ligamentum flavum and retrocorporal calcification. SCHMORL & JUNGHANNS (1952) observed retrocorporal calcification only in one of 10 000 cases examined post mortem but more frequently calcification of the ligamentum flavum, often associated with diseases causing rigidity of the spine (spondylarthrosis, senile kyphoscoliosis). These changes would appear to occur much more frequently and can usually be demonstrated by careful roentgen examination of the cervical part of the spine.

ONJI & AKIYAMA (1965) have attributed compression of the cervical cord in 18 Japanese patients with myelopathy to encroachment by a calcified posterior ligament. Subsequently MINAGI & GROSSNER (1969) as well as HIRAMATSU & NOBECHI (1971) have suggested that Japanese subjects tend to have more calcification in the ligaments than do Caucasians.

In the course of the past 11 years a total of 8 700 patients of Caucasian origin has been subjected to roentgen examination of the cervical spine because of cervicobrachial symptoms. Of these 101 had calcification of the posterior longi-



Fig 11 Dural calcifications posteriorly and anteriorly

tudinal ligament and disc degeneration combined with myelopathy was evident in 8 patients 14 had suffered trauma

Case reports

Case 1 Male aged 24 One year after compression fracture the posterior longitudinal ligament behind the fractured vertebra was calcified (Fig 7)

Case 2 Femal aged 28 had fallen on her head 5 years previously from a tractor Complained of headach Calcification of th posterior longitudinal ligament between C3 and C4 (Fig 8)

Case 3 Female aged 29 complained of cracks in her neck when taking her child weighing 20 kg on her neck Extensive calcification f the longitudinal posterior ligament between C3 and C5 (Fig 9)

Case 4 Female aged 5? complained f frequent headache Calcification f th posterior longitudinal ligament between C2 and C4 (Fig 10)

Case 5 Femal aged 35 complained f headache Calcification f th dura nteriorly as well as posteriorly C3—C6

Case 6 Male aged 47 had been hit by stone slide in mine 26 years before without bone lesion H presented with pain in the neck and headache Radiography revea ec similar ossification f th dura (Fig 11)

Discogenic lesions of the spinal cord were first reported in 1940 by Stoc-ey later by Bucy et coll (1948) Frykholm (1951) Brain (1954) Liversedge et coll (1963) Clarke (1955) MacDonald (1955) O Connell (1955) Seoerberger (1956) and Baltavary (1956) Cloward (1958) distinguished three groups (1) Acute rupture of the disc (2) Slowly developing degenera

tion of a disc Symptoms and signs develop slowly neuralgias and pareses are occasionally followed by spastic paralysis 3 Protrusion or herniation of a disc into the spinal canal Symptoms and signs are similar to those of a spinal tumour Group 2 is most frequently observed

The radiologic diagnosis is accomplished by myelography which however often fails to demonstrate the filling defect caused by disc herniation especially if it is located laterally Discography a more direct method has also been used

As neither myelography nor discography is indifferent for the patient we have tried to make maximum use of the extension technique In the vast majority of cases the ligament calcifications and protrusion of the disc could be demonstrated Our observations are in agreement with those of Meyers et coll 1955 who *compared the myelographic changes with those seen in con*ventional film They found no correlation between the osteophytes on the anterior and lateral edges of the vertebrae and the lesions demonstrated by myelography On the other hand an osteophyte on the posterior edge indicated the site of compression in 31 of 35 cases Similar osteophytes of the posterior edge above or below the protrusion or herniation were often encountered also in our material

Bad results of surgery are often encountered partly due to the fact that operation was performed too late when irreparable lesions of nerve structures already has appeared The lateral film taken during anteflexion and traction combined with sagittal tomography can be carried out at a time when symptoms and signs are still scanty thus facilitating an early diagnosis

SUMMARY

For the diagnosis of cervical ligament and dura thickenings as well as disc myelopathies myelography is generally adopted method In early cases patients are not willing to give their consent to this examination but in late cases the result of operation is rarely satisfactory By special device exerting traction on the head and bringing the neck into anteflexion the number of cases diagnosed on conventional roentgenograms or possibly supplemented by sagittal tomography can be increased whereby myelography will in many cases become superfluous

ZUSAMMENFASSUNG

Zur Diagnose der zervikalen Ligament und Dura Verdickungen sowie bei Bandscheiben Myelopathien ist die Myelographie eine allgemein akzeptiert Methode In fruhen Fallen sind die Patienten nicht gewillt ihre Zustimmung zu dieser Untersuchung zu geben wahrend in spaten Fallen das Ergebnis einer Operation selten zufriedenstellend ist Durch eine spezielle Anordnung mit der der Kopf einem Zug unterstetzt und der Hals in Anteflexion gebracht wird kann die Zahl der diagnostizierten Fallen mit konventioneller Rontgentechnik moglicherweise erganzt durch sagittale Tomographie gesteigert werden wodurch eine Myelographie in vielen Fallen uberflussig wird

RÉSUMÉ

La myélographie est une méthode généralement adoptée pour le diagnostic des épaississements des ligaments cervicaux et de la dure mère ainsi que pour les myélopathies d'origine discale. Dans les cas de début les malades ne veulent pas donner leur consentement à cet examen alors qu'à un stade tardif le résultat de l'opération est rarement satisfaisant. Un dispositif spécial exerçant une traction sur la tête et amenant le cou en flexion antérieure permet d'augmenter le nombre des cas diagnostiqués sur les radiographies simples ou éventuellement complétées par tomographie sagittale ce qui rendra la myélographie superflue dans de nombreux cas.

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FROM THE DEPARTMENT OF RADIOLOGY ST THOMAS HOSPITAL AND MEDICAL SCHOOL, LONDON SE1 7EH ENGLAND

PHLEBOGRAPHY IN THE KLIPPEL-TRENAUNAY SYNDROME

M LEA THOMAS and G B MACPHIE

KLIPPEL & TRENAUNAY (1900) described a clinical syndrome consisting of a naevus confined to one lower limb varicose veins on the same side dating from birth or infancy and hypertrophy of bone and soft tissues of the affected limb Their description made no mention of symptoms or signs suggestive of an arteriovenous fistula Since then there have been a large number of reports of a similar syndrome (PARKES WEBER 1907 NAZARRO 1954 SERVELLE 1964 LINDENAUER 1965 1971 LANGERON & VERCAUTEREN 1970) to name only a few Other authors include in the term Klippel Trenaunay syndrome patients with arteriovenous fistula (PARKES WEBER 1918 1949 HARRIS & WRIGHT 1929 BLUMGART & ERNSTENE 1932 CULLITY 1951 GALICER & NERIO CHICOTE 1956 BOUVRAIN & BOURTHOUMIEUX 1957 DESMONS & PELCE 1957 COTTON & SYKES 1969) Generally however the view is now accepted that the term Klippel Trenaunay syndrome should be reserved for a purely venous dysplasia (MALAN & PUGLIONISI 1964 LINDENAUER 1965 1971) Such a limitation in terminology is of practical value as the management and the prognosis are affected by the presence of arteriovenous shunting

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Fig 1 Case 11 Left leg Varicose veins [illegible] naevus and soft tissue hypertrophy

SERVELLE (1945) was the first to describe the use of phlebography to demonstrate the venous abnormality in Klippel Trenaunay syndrome Since then it has become widely practiced (MEYERS & JONES 1955 FECK 1957 SERVELLE 1957 FOSTER & KIRTLEY 1959 MARTORELL & MONSERRA 1962 ODA et al 1962 LINDENAUER 1965 LEA THOMAS & ANDREWS 1971)

The phlebographic findings in 14 patients with the Klippel Trenaunay syndrome are described in this report The clinical features and other radiographic findings are briefly recorded

Material Fourteen patients with the Klippel Trenaunay syndrome were investigated by phlebography Six patients were male and eight female All patients had a cutaneous naevus noted at birth and nine of these presented at this time one presented at 2 one at 5 one at 11 and two at 17 years

All the patients had varicose veins In eight patients there was bony hypertrophy and in ten there was thickening of the soft tissues (Fig 1) Eight patients had oedema of the legs Cutaneous naevi were present on the right leg in eight patients on the left in five and in one patient the naevus was bilateral though



Fig 2



Fig 3a



Fig 3b

Fig 2 Case 1 Peripheral phlebogram of right leg Deep venous system of the thigh absent

Fig 3 Case 6) Peripheral phlebogram of right leg There are large la eral enous trunks connecting w th the profunda system b) Direct injection phlebogram Th arico lateral trunk is more clearly demonstrated

greater on the right leg than on the left Art riography was carried out in six patients and conventional films of the affected limb taken in four The finding are summarised in Table 1

In some patients no treatment was indicated In others the treatment consi t of conservative measures only tying of varicose veins ligation of venous tru k relief of obstruction and excision of subcutaneous fat The type of treatm and its results are shown in Table 2

Phlebography The phlebographic techniques used have been described in detail elsewhere In mo t instances phlebography by injection of foot veins was

Table 1

Clinical features and phlebographic findings

Case and sex	Age at presentation	Affected leg	Bone hypertrophy	Soft tissue hypertrophy	Oedema	Other symptoms	Conventional films
1 M	17	R	–		+	Pain	–
2 F	17	R		+		–	–
3 F	5	R	+	+	+	Cellulitis	–
4 F	Birth	L				–	–
5 M	Birth	R	+	+		–	1 cm length[illegible]ng
6 F	Birth	R	–		+	Pain	–
7 M	Birth	R	+	+		Bleeding	–
8 F	2	L	–	+	+	Pain	Perio[illegible]
9 M	Birth	L	+	+	+	–	1 cm l[illegible]ng
10 F	11	L	–	+	+	–	
11 M	Birth	Both	+	–	–	–	–
12 F	Birth	L	+	–	–	Thrombophlebitis	Phlebolith
13 M	Birth	R	+	+	+	Haematuria from bladder angioma	–
14 F	Birth	R	+	–	–	–	–

Tabl 1 (cont)

Arterio-graphy	Type of phlebogram	F ndings
–	Peripheral phlebogram	Absent calf nd femoral eins lateral enous trunk with perforating eins joining profunda ein enous angioma of foot
+	Peripheral phlebogram	D lated superficial eins normal deep eins
+	Peripheral phlebogram direct njection	Absent femoral ein incompetent perforating eins of calf lateral enous trunk
–	Peripheral phlebogram	Absent deep eins of calf nd thigh
+	Peripheral phlebogram	Normal deep eins incompetent perforating eins of calf
–	Peripheral phlebogram direct injection	Normal deep eins lateral enous channels joining profunda nd common iliac eins
–	Peripheral phlebogram	Normal deep eins Hunter canal incompetent perforating ein lateral enous trunk entering common ilia ein
+	Peripheral phlebogram direct injection	Normal deep eins incompetent perforating eins of calf antero-medial enous trunk
+	Peripheral phlebogram	Hypoplas of deep eins of calf incompetent thigh perforating eins en ering profunda ein lateral enous trunk jo ning common ilia ein
–	Peripheral phlebogram traosseous percalcaneal jection intraosseous pertrochanter injection	Normal deep eins incompetent perforating eins of the calf lateral enous trunk joining common iliac in
+	Peripheral phlebogram intraosseous per calcaneal inject on intraosseous pertrochanteric injection	Normal deep eins incompetent perforating eins of the calf lateral enous trunk jo ning common iliac ein
–	Peripheral phlebogram direct injection R perfemoral njection L pertrochanteric inj ction	Normal deep eins of calf bsent upper left femoral external and internal iliac eins lateral enous trunk entering right internal iliac ein
–	P ripheral phlebogram	Ab t deep eins of calf la eral enous trunk jo ning femoral ein in mid thigh
–	Peripheral phlebogr m	Ab ent deep ns lateral enous tru k in h pass ng medially to join femoral ein in u er thigh

T bl 2

T eatment a d result

Case	Tre	Result
1	F f h ang ma	mpr en ent
	I g t f n se em	Temporary impr ement
3	N	
4	F cision f aric s n	Imp emen
	C ers n	
6	Liga f ric se	Temporary mpr er t
7	Liga f arico ens exci f I ema gi ma	Impr ement
8	Liga f aric em exci f beut neo s fat	Impr ement
	N ne	
10	L g f aric em	Imper ement
11	Rel f f I ac bstruction cru f en trunk	Impr ement
12	N ne	
13	N	—
14	N	

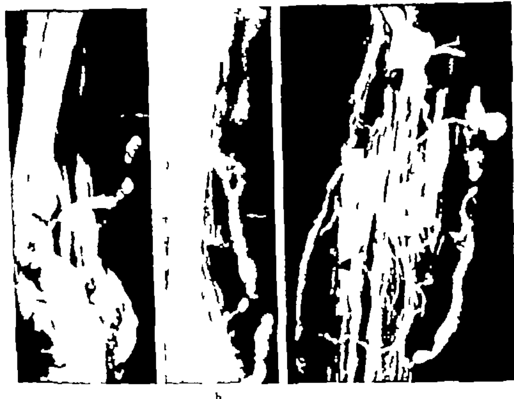
adequate to demonstrate the whole deep venous system (Lea Thomas et coll 1971 Lea Thomas 1972 In 2 patient thi was supplemented by direct injec tion of ontrast into a uperficial varicosity to show its deep connections Lea Thomas & Andrews 1971 In addition to peripheral phlebography per aka neal and p rtrochanteric injection were requir d in one patient to demonstrate the whole of the deep venous system combined pertrochanteric and perfemoral techniques were employed in a second and bilateral perfemoral in a third patient (Lea Thomas & Fletcher 1967 The technique used to demonstrate incom petent perforating vein ha also been described Lea Thomas et coll 1972

Arteriography was carried out by femoral arterial puncture and the u of a rapid series of films using an automatic film changer

Results

In all cases extensive dilated superficial veins were demonstrated not especially associated with the long and short saphenous groups (Figs 3 8)

Eleven cases had large valveless dilated enous trunks usually situated on the lateral aspect of the leg (Figs 3 4 6 b 7 8) The dilated venous trunks entered the profunda vein (Fig 3 a) the femoral vein or the veins of the pelvis (Figs 5 6) They frequently had multiple drainage into the deep venous system (Figs 3 a 4 c)



b

Fig 4 Case 8 Peripheral phlebogram of left leg) Lateral view of foot and ankle b) P view A tero-medial enous trunk (→)) Incompetent perforating eins (→) connecting enous trunk with the deep eins

In seven cases enlarged perforating veins were demonstrated in the calf (Fig 4 c) In addition to these there were often perforating veins joining the venous trunks to the profunda vein or the femoral ein (Fig 3 a) These perforating veins were often incompetent

In four patients the deep veins of the lt and thigh were absent (Figs 2 7) in two the femoral vein alone was absent Fig 6) and in one patient the deep calf veins only were absent

In one patient the whole of the deep venous sy tem was hypoplastic as far a the upper femoral vein In one patient ther was a stenosis of the external iliac vein thought to be due to compression by a nearby artery and in another the left external and common il a ins were occluded (Fig 6 a)

In two patients the d venous system appeared normal apart from incompetent perforating veins n calf The findings are summarised in Table 1



Fig 5 (9) Bilateral perfemoral phlebogram I ft external common nd ter l iliac eins con iderably d lated superior gluteal ein al d l ted b) Peripheral phlebogra Large lateral enous trunk joining left common iliac ein

Arteriography All arteriographies were normal In the later phases f the examination the deep veins could sometimes be faintly made out, giving further information as to the patency or otherwise of the deep venous system

Conventional films of the affected limbs were taken in four patient All showed thickening of the soft tissues 2 lengthening of bones 1 periostitis of the tibia and fibula and 1 phleboliths (Table 1)

Discussion

The clinical features of our patients were typical of the entity now generally accepted as the Klippel Trenaunay syndrome In all but one patient, the lesions were present in only one lower limb and in the remaining patient although the lesions were bilateral they were more marked on the right side than on the left Bilateral involvement has been previously described (KUFFER et coll 1968) and



FIG 6 Case 1) Combined right perfemoral and left intraosseous pelvic phlebogram Upper femoral and iliac eins absent on the left Collateral ins bypass the occluded segment b) Direct injection phlebogram A dilated alv less anomalous trunk draining into the right internal iliac vein

even involvement of all 4 limbs (LAMAR et coll 1965) The cutaneous naevi were always noted at birth but tended to become more obvious with age They were predominantly on one lower limb but extended in ome instances onto the buttock and the lower thorax The dilated superficial veins were usually extensive ometimes forming a plexiform network (FIG 9) There was increased length and size of the affected limb in most of our patients There was no clinical evi dence such as increased warmth pulsating varicosities a thrill or bruit or a positive Branham sign which would suggest the presence of an arteriovenous fistula No early filling of veins was observed nor increased tortuosity of branches nor enlargement of the main arteries which would suggest arteriovenous shunting As bilateral femoral arteriographies were carried out it was possible to compare the diameters of the arteries on both sides (FIG 9) Because there was no evidence of arteriovenous fistulas the cause of limb hypertrophy is not clear but hypertrophy has been attributed to venous stasis (SERVELLE 1945 PACK & MILLER 1950 LACROIX 1951 MALAN & PUGLIONISI 1964 WORTZEL 1966 BARIETY et coll 1967)

The aim of phlebography is to demonstrate as fully as possible the d p e nous system in order to show its patency any obstructing lesions and bnormal superficial channels

In the presence of dilated superficial veins the demonstration of the deep venous system can prove difficult (KERT & GRISHMAN 1945 MEYERS & JONES

1955 MALAN & PUGLIONISI 1964 Editorial Trans St John Hosp Derm Soc 1966) The most reliable method is intraosseous phlebography from the medial malleolus (HALLIDAY 1968) but this method carries the hazard of necrosis of a developing epiphysis in young people An intraosseous phlebogram to show the iliac vein was used in one of our young patients (Case 10) without incident but it was resorted to as the only method available to fill the deep venous system in the presence of an occluded femoral vein (Fig 6)

Factors which improve the chance of deep venous filling are injecting contrast towards the toes i e in an upstream direction so that the contrast passes through communicating veins in the dorsum of the foot directly into the deep venous system (HALLIDAY 1968) A steep table tilt and tight tourniquets around the ankle adjusted under screen control are also helpful Care must be taken however when the deep venous system is absent or hypoplastic as the contrast medium may be trapped in the foot causing tissue damage which may lead to gangrene (LEA THOMAS 1970) Indirect phlebography i e injection of large volumes of contrast (50 ml or more) into the femoral artery with follow through to the venous phase may give some additional information about the state of the deep venous system (LEA THOMAS & ANDREWS 1971)

The phlebographic findings in our patients are similar to those described by others These included absence or hypoplasia of the deep venous system in whole or in part (SERVELLE 1945 SERVELLE et coll 1957 LINDENAUER 1965 1971) venous obstruction caused by adjacent arteries (SERVELLE et coll 1957) and complete absence of a common and external iliac vein (SERVELLE 1945 OLIVIER 1955 SERVELLE et coll 1957 MALAN & PUGLIONISI 1964 LOULETT & LEFF 1969)

The state of the deep venous system is fundamental to management If an obstruction is present it may be relieved by surgical reconstruction as reported by others (SERVELLE et coll 1957 LINDENAUER 1957) Such a surgically operable lesion is however rare Stripping and tying of superficial varicose veins in patients with deep venous obstruction worsens the symptoms producing further varicose veins and oedema (FOSTER & KIRTLEY 1959 MALAN & PUGLIONISI 1964 LINDENAUER 1971) Such patients are best treated with simple supportive measures such as elastic stockings Thus the most important aspect of the investigation of patients with Klippel Trenaunay syndrome is to demonstrate any abnormalities of the deep venous system

Many attempts have been made to classify the angiodysplasias GOIDANICH & CAMPANACCI (1962) suggested a division into superficial and deep localised or diffuse but did not distinguish between those with or without an arterial element The long term prognosis in patients with a purely venous angioma is much better than that of a congenital arteriovenous fistula (MALAN & PUGLIONISI 1964 LEA

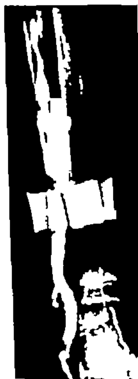



Fig 7



Fig 8



Fig 9

Fig 7 Case 13 Peripheral phlebogram right leg Dilated valveless venous trunk on lateral aspect of leg Deep venous system absent in the calf

Fig 8 Case 14 Peripheral phlebogram of right leg Deep veins of the calf absent lateral venous trunk

Fig 9 Case 1 Peripheral phlebogram of right foot Extensive plexiform network of superficial veins

ntsxuri 1965 Lditorial Tran St John Hosp Derm Soc 1961) It i therefore important to make a di tinction between these group Recogni ing thi MALAN & PUCLIOSE separated off the venou dy plasia and ubdivided them into four groups phlebectasia phlebangioma phlebangiomatosis and a combination of all thre An attempt to further simplify the classification of venous dy pl sia has been ugge ted by LEA THOMAS & ANDREWS (1971) These authors uggest that angiographically there are two basic types one in which the principal abnormality con i t of dilated venous trunk and the other consi ting mainly of avernous spac For the former they use the term phlebecta ia and for the latter venou angioma The Klippel Trenaunay syndrome fall into the former group

However the triad described by KLIPPEL & TRENAUNAY of unilateral vari ose vein utaneous naevi and bony and soft tissue hypertrophy i a fairly well defined ntity For these reasons it is uggested that the t rm Klipp l Trenaunay syndrome should be retained

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SUMMARY

The pl lebogr phic findings in 14 p tient w th Kl ppel Tren un y h e de- cribed Th mo t import nt find g al ence or hypopl f the deep enou tem Other f nding n lude exten iv v ri n d l ted ven us trunk nd enl ed per f t ng ein Surg l interrupti n f uperfici l v in the presen f n l m l deep tem m y worsen the mptoms It ugg ted th t the t rm Kl ppel T en u y n drome hould be retained but m pl yed es lu iv ly for p tient ith the tri l f unilater l se ms utaneous evi nd h pertrophy of bone nd ft t ues with ter enou f t l

ZUSAMMENFASSUNG

D phl bogr phi hen Befunde bei 14 l tenten mit Klippel Tren un Syndrom erden I eschr eben Der wichtigst Befund i t d Fehlen oder die Hyp plasie des tiefen Venen y tems Ander Befunde umf sen exten iv v rik Venen dil t ert Venentr nk und erweitert perforierende Venen I wird hervorg hoben l ss eine Hlebogr phie r der H legung der B h ndlung der Patienten mit einem Kl ppel Trenaunay S ndrom vorg nommen werden sollt Eine hirurg he Unterbrechung der oberfl hlichen Venen m Gegenwart eines bnorm tiefen Sy tem konnen d e Sympt m verschlechtern I wird v ge hl gen den Begriff Kl ppel Trenaunay S nd om beizubeh lten jed h u sc hlie lich nur bei den P tienten anzuwenden bei denen die T ad der unil teralen v rik en Venen cutaner N und der Hypertrophie der Knochen und weichen Gew e ohne arteriov en F t l vorliegt

RÉSUMÉ

Description des signes angiographiq es chez 14 malades atteints d syndrome de Klippel Trenaunay Le signe le plus important est l absence ou l hypoplasie du système eineux profond Les autres signes comprennent des veines variqueuses etendues des troncs eineux dilates et des eines perforantes dilatees L interruption chirurgicale des eines superficielles quand le système veineux profond est anormal peut aggra er les symptomes Les a teurs pensent qu il faut garder le term de syndrom de Klippel Trenaunay mais le reserver exclusivement aux malades qui presentent la triade de eines variqueuses unilaterales naev cutanes et hypertrophie de l os et des parties molles sans fistule arterio-veineuse

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SCINTIGRAPHY AS A SCREENING TEST FOR CARCINOMA OF THE PANCREAS

K WATANABE, K KAWAHIRA and K MATSUURA

Carcinoma of the pancreas is difficult to detect sufficiently early for successful surgical treatment (CATTEL & PYTREK 1949 DENNIS et coll 1956 PORTER 1958) the symptoms and signs are nonspecific and no simple and accurate means of diagnosis is available Methods such as pancreatic duodenography duodenal fiberscopy selective abdominal angiography and splenoportography are all difficult to perform A more simple yet accurate examination is available in scintigraphy although it carries its own problems Only 4 to 7 per cent of th dose of Se-Selenomethionine administere d is taken up by the gland (BLAU & MANSKE 1961 BLAU 1961 1964 LAP N RAZZAK 1969) most of it bein concentrated in the liver The liver and p ncreas are in close anatomic relatio ship o that it is often diff ult to separ them in a scintigram in additi n the pancreas lies deep in t e body so that a arcut outline is hard to obtain

This investigation was p formed in pat ts with various pancreatic di orders in order to obtain more rmation the clinical significance of such an examination as a screenin st for carcino of the pancreas

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Table I

Classification of cases

Diagnosis	Verification: Proven cases	Clinical diagnosis	Total
Carcinoma	31	8	39
Pancreatitis	10	33	43
Normal	3	9	
Others	19	13	[illegible]
Pancreatic cyst	4	0	4
Islet cell tumour		0	
Choledochus cyst	4	0	4
Retroperitoneal tumour	5	0	
Pancreas metastases	4		
Diabetes mellitus	0	11	11
Total	83	113	[illegible]

Material The various pancreatic disorders of the 196 cases examined are classified in Table 1. The diagnosis of 83 of the cases was confirmed at operation or autopsy while this was suggested in 113 cases by symptoms, signs and [illegible] laboratory examinations. Thirty nine cases with jaundice, ascites and an abdominal mass were considered as having carcinoma of the pancreas and diagnosed by roentgen examination and pancreatic duodenography; in 31 of these the diagnosis was confirmed by histology. Pancreatitis was in 43 cases diagnosed by roentgen examination, serum and urinary amylase activities and the pancreozymin secretin test; in 10 of these cases it was confirmed by histology. A retroperitoneal mass, a pancreatic cyst, an insulinoma and other malignant metastases were revealed at laparotomy.

Method A dose of 250 μCi Se Selenomethionine was administered intravenously and followed 30 minutes later by a scintigram of the pancreas. The patient lay supine with the scinticamera (Nuclear Chicago Pho/Gamma III) set at an angle of 5 from the vertical and directed toward the head; the exposure was preset for 1.2×10 counts. Hepatic scintigraphy was then carried out following the intravenous injection of ^{198}Au colloid or ^{99}Tc colloid.

Scintigrams were divided into five groups: localized defect, total defect, faint demonstration, displacement, and normal. A normal scintigram of the pancreas is featured in Fig. 1. A localized defect scintigram indicated a partial defect in the normal contour of the pancreas (Fig. 2). A total defect meant that no



Fig 1 Normal pancreas



Fig 2 Localized defect (Carcinoma of pancreas)



Fig 3 Total defect (Carcinoma of pancreas)

radioisotope uptake was observed in the pancreatic region (Fig 3) Fig 4 presents a faint scintigram of the pancreas with less uptake of radioisotope compared with that of the normal Displacement of the pancreatic scintigram is evident in Fig 5

Results

Twentytwo of the 39 cases of carcinoma of the pancreas had a localized defect in the pancreatic scintigram A total defect occurred in 14 cases indicating an abnormal scintigram in 92 per cent of the cases The remaining 3 cases (8 per cent) failed to present any abnormality

The scintigram was normal in 19 cases (44 per cent) and presented a localized defect in 8 (19 per cent) faint demonstration in 7 (17 per cent) and a total defect in 9 (21 per cent) of the 43 patients with pancreatitis Normal scintigrams were obtained in 73 cases (89 per cent) faint demonstration in 6 (7 3 per cent) total defect in 2 (2 4 per cent) and displacement in 1 case (1 2 per cent) of the normal part of the material

The 38 cases with a localized defect w re evaluated Twentytwo cases (58 per cent) had carcinoma 8 (21 per ce pancreatitis and the remaining 8 case had other disorders such as pancr ic it insulinoma metastases and retroperitoneal tumour No cases with a l lize defect were normal

Of 16 cases with faint scin r 7 cases (44 per cent) had pancreatitis 6 (37 per cent) were normal ar 3 per cent) had diabetes No case of carcinoma of the pan as had a a r am

A total of 33 cas th a t the pancreatic scintigram was made up of 14 cases (42 r ent) of ic carcinoma 9 cases (27 per cent) of

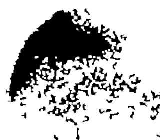


Fig. 4. Faint demonstration (Chronic pancreatitis)



Fig. 5. Displacement (Retroperitoneal tumour)

pancreatitis and 8 cases (24 per cent) of other disorders such as diabetes, a retroperitoneal tumour and metastases from other organs. The 9 cases with displacement of the scintigram consisted of 3 of pancreatic cyst, 3 of obstruction of the bile duct, 2 of retroperitoneal tumour and 1 normal case.

The 100 cases with normal scintigrams were analyzed: 73 cases (73 per cent) were free from pancreatic disease, 19 cases (19 per cent) had pancreatitis and 8 cases (8 per cent) had other pancreatic disorders.

The site of the carcinoma of the pancreas established at operation or autopsy was compared with the scintigraphic findings in 28 cases (Table 2). Complete agreement between the situation of the neoplasm and that of the defect in the scintigram was evident in 10 out of 28 cases (36 per cent). The size of the defect was usually greater than that of the tumour.

Table 2

Diagnostic accuracy of the localization of pancreatic carcinoma by scintiscanner (total no. of 28 cases)

	Localized defect					Non visualized	Normal findings
	Head	Body	Tail	Head body	Body tail		
Head							
Body							
Tail							
Head body							
Body tail							
Total pancreas							

Correct diagnosis 10/28 36

Carcinoma of the head of the pancreas produced a total defect in the scintigram in 5 out of 8 cases, a localized defect being caused in 2 and a normal scintigram occurred in one case. Four cases with carcinoma of the body of the pancreas were made up of 1 case of total defect and 3 suggesting localized defects in the head or tail regions.

Discussion

No reliable means for early detection of carcinoma of the pancreas is available at present. Roentgen examination of the upper part of the digestive tract is however generally considered the method of choice for the examination of cases of possible carcinoma of this gland, making the detection rate 50 to 60 per cent (GULLIK 1959, GOSWITZ 1961, EYLER et coll. 1962, ANSARI & BURCH 1970). It is also well recognized that pancreatic scintigraphy is useful in the diagnosis (SODEE 1966, RODRIGUEZ ANTUNEZ et coll. 1966, BROWN 1968, EATON et coll. 1968, FINK et coll. 1969, HATCHETTE et coll. 1972, HESLIP & OVERTON 1971).

The present investigation revealed that 36 (92 per cent) out of 39 cases of carcinoma of the pancreas had abnormal scintigrams with localized or total defects. This finding agrees well with those of previous workers (BROWN, EATON et coll., FINK et coll., HATCHETTE et coll., HESLIP & OVERTON, RODRIGUEZ ANTUNEZ et coll. 1966, SODEE 1966). The results must however be revised with due consideration to the extent or the size of the growth. A large pancreatic carcinoma is relatively easy to discover. Although the detection of a neoplasm 2 cm in diameter by scintigraphy has been reported possible (LIEWENDAHL & KIVIST 1970, SODEE 1964), the present 2 cases with a carcinoma over this size were not successfully demonstrated. The malignant tissue was situated in the region of the body and tail of the pancreas and the scintigrams were interpreted as being due to a short pancreas. This indicates the difficulty in recognizing a localized defect in scintigrams and is particularly true with such tumours at an early stage. The sensitivity of scintigraph[illegible] revealing early carcinoma is [illegible] doubtful although the possibility of th[illegible] being of [illegible]alue in the diagn[illegible] was well supported by the present inv[illegible] which disclosed that over 90 per cent of the cases affected had abnormal pa[illegible]tic scintigrams.

Twentyfive cases of 38 with a local[illegible]ed [illegible] and 16 of 33 cases with a total defect had a malignant condition of [illegible]. Approximately 57 per cent of the cases with localized or total def[illegible] th[illegible] pancreatic scintigram therefore had a malignant growth; the other 43 per cent of these abnormal scintigrams was however due to disorders other than a neoplasm, supporting the previous reports of 15 to 30 per cent for false positive results (BROWN, RODRIGUEZ ANTUNEZ et coll. 1966, SODEE 1966). The number of false negative scintigram of

carcinoma of the pancreas is however low. A normal scintigram excludes a new growth (RODRIGUEZ ANTUNEZ 1968, BROWN, BURDINE & HAYNIE 1965, FINK et coll. LIEWENDAHL & KVIST 1970, LANDMAN et coll. 1971, STAAB et coll. 1971). The conclusion may therefore be reached that scintigraphy constitutes a most useful screening test.

The utilization of scintigraphy for localization as well as for the determination of tumour size was evaluated in the present work. for these purposes it proved of less value. Carcinoma of the gland is usually complicated by pancreatitis (BARTHOLOMEW et coll. 1958, PALLINO NETTO et coll. 1960, LORBER & CHEN 1969) so that a defect larger than the true size of the tumour is obtained.) out of 8 cases with carcinoma of the head had a total defect.

The potential genetic damage in the use of a relatively high gonad dose of Se Selenomethionine (SODEE et coll. 1965) administered to patients with possible pancreatic carcinoma must be borne in mind. The incidence of carcinoma is more common however in the age group of 60 years and over (ANSARI & BURCH, ACKERMAN & DEL REGATO 1962, LOWE & PALMER 1967), consequently the hereditary effects of the test may perhaps be ignored.

SUMMARY

An investigation was performed in 196 cases to evaluate scintigraphy as a screening test in the diagnosis of carcinoma of the pancreas. Ninety-two per cent of 39 cases of malignancy had a localized or total defect in the scintigram, although the false positive rate of the material was 43 per cent. On the other hand normal scintigrams excluded carcinoma. The test appears to constitute a useful means for the diagnosis in this condition.

ZUSAMMENFASSUNG

Es wurde eine Untersuchung an 196 Fällen vorgenommen, um die Szintigraphie als Screening-Test für die Diagnose eines Pankreaskarzinoms klarzulegen. 92 % der 39 Fälle mit einem malignen Geschehen hatten einen lokalisierten oder totalen Defekt im Szintigramm, wobei die Frequenz falscher positiver Fälle des Materials 43 % betrug. Andererseits schließt ein normales Szintigramm ein Karzinom aus. Dieser Test scheint zu bestätigen, dass die Szintigraphie ein brauchbares Verfahren für die Diagnose dieser Erkrankung darstellt.

RÉSUMÉ

Les auteurs ont fait un travail de recherche sur 196 cas pour apprécier l'intérêt de la scintigraphie comme épreuve de dépistage dans le diagnostic du cancer du pancréas. Quatre-vingt douze pour cent des 39 cas de tumeur maligne présentaient une zone localisée ou totale de défect d'activité sur le scintigramme, cependant la proportion de faux positifs pour la série était de 43 pour cent. D'autre part des scintigrammes normaux excluent un cancer. Cette épreuve paraît constituer un moyen utile pour le diagnostic de cette affection.

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RADIOLOGIC DIAGNOSIS OF ILEAL CARCINOID TUMOURS

E Boijsen J Kaude and U Tylén

Carcinoid tumours arise from the argentaffin cells of the gastrointestinal tract They may be located anywhere from the cardia to the rectum and originate in any tissue derived from the primitive endoderm Carcinoid is a slowly growing well delineated tumour with a diameter of 0 5 to 3 cm usually situated in the submucosa of the bowel wall (Moertel et coll 1961 Sanders & Axtell 1964 Simpson 1969 and others) Multiple small bowel carcinoids are present in some 25 per cent of cases About 3 000 carcinoid tumours have been reported some 45 per cent of which were in the appendix and almost 30 per cent in the jejunum ileum (Darle 1972)

Despite the fact that the primary growth arising from the small bowel wall is small extensive local lymph node involvement and large hepatic metastases often occur The Swedish Cancer Registry (197) recorded metastases in a out 45 per cent of cases The highest frequencies ere listed in colonic (a ndix ex

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cluded) and ileal carcinoids 66 per cent and 53 per cent respectively MOERTEL et coll (1961) reported a definite relationship between the size of the primary neoplasm and the presence of metastases Those carcinoids that originate from the appendix seldom produce metastases (MOERTEL et coll 1968)

Some carcinoid tumours cause a mild form of diarrhoea Most of them however produce no symptoms and are therefore frequently found incidentally at autopsy Carcinoids may also lead to intestinal obstruction which is usually secondary to a fibroplastic change in the mesentery and adhesions. Less often the main symptom is haemorrhage The origin of bleeding may be the tumour itself ischaemic ileal necrosis due to involvement of mesenteric vessels or ulceration of the stomach or duodenum MACDONALD 1956 DARLING & WELCH 1959 GOOD 1963 ANTHONY & DRURY 1970 HORSLEY & BAUER 1970) A malabsorption syndrome with steatorrhoea observed by KOWLESSAR et coll (1959) was thought to be secondary to local carcinoid metastases causing occlusion of mesenteric veins

The carcinoid syndrome is produced by the release of 5 hydroxytryptamine (serotonin from the metastases It is characterized by intestinal signs valvular disease of the right heart peripheral vasomotor symptoms and signs, and cyanosis (THORSON et coll 1954 and others)

The diagnosis of a carcinoid tumour of the small bowel may be made by a barium examination A combination of kinked bowel loops and small intraluminal filling defects are typical (MILLER & HERRMANN 1942) KOWLESSAR et coll (1959) and HUDSON & MARGOULIS (1964) observed that occlusions of mesenteric veins by the neoplasm cause oedema of mucosal folds which at small bowel examination may give the appearances of regional enteritis or sprue The similarity between the small bowel changes in Crohn's disease and carcinoid growths was also reported by STARK et coll (1961) and WOOD et coll 1970) Despite the fact that these changes may occur in ileal carcinoids, a correct preoperative diagnosis is seldom made The reason for this is that most lesions cause not only the above changes but produce minor alterations that are not recognised as arising from carcinoids (BLUTH 1960 GOOD 1963 HUDSON & MARGOULIS 1964)

The angiographic appearances in two cases of ileal carcinoids were described in 1966 (REUTER & BOIJSEN) The characteristic findings seemed to be the radiating arrangement of the vasa recta and the smaller intramesenteric arteries due to retraction of the mesentery and narrowing or occlusion of mesenteric arteries and veins Since then these findings have been verified in additional reports (MARSCHAK & LINDNER 1970 BOIJSEN 1971 SIEMERS et coll 1971 CLAPS et coll 1972) The same changes were not observed in one case of a gastric carcinoid (ANDERSEN et coll 1971)

Angiography was reported in a few patients with hepatic metastases from carcinoids (LUDIN et coll 1966 NEBESAR et coll 1966) the metastases were generally very vascular

The preoperative diagnosis of carcinoid tumours of the gastrointestinal tract thus appears seldom to be made unless the rare syndrome is present Even then it may be impossible to locate the primary tumour by a barium examination of the small bowel despite the fact that it is recognised that ileal carcinoids are almost exclusively responsible for the syndrome The few reports on the angiographic findings in carcinoid tumours do not permit of definite diagnostic conclusions The present investigation may therefore add further experience, mainly in angiography regarding both the primary ileal carcinoid and its local and distant growths

Material and Methods A total of 15 patients (9 males, 6 females) aged from 32 to 75 with proven carcinoid tumours of the ileum were examined over a period of seven years (1964 to 1971) Three of these have been reported previously (REUTER & BOIJSEN 1966 BOIJSEN 1971) The main symptoms and signs were diarrhoea in 11 patients abdominal pain in 12 weight loss in 6 and gastrointestinal bleeding in 3 patients Two patients had the malabsorption syndrome with steatorrhoea The 5 HIAA at the time of the radiologic examination was elevated in all 11 patients who underwent this test 9 of these had signs and symptoms of flushing Survey films of the abdomen were always available and a barium examination of the small bowel was performed in 12 patients.

Angiography of the superior mesenteric artery was carried out in all 15 patients and celiac or hepatic angiography in 12 patients The indications for angiography varied these in 4 patients being a palpable abdominal mass and bowel obstruction in 2 patients the indication was acute gastrointestinal bleeding The presence of carcinoid metastases were known before angiography in 7 patients, by fine needle biopsy of the liver in 5 of an axillary lymph node in one and of a tumour of the sterno-costal border in one patient The discovery of malignancy was quite unexpected in 2 patients one was examined by angiography because of hepatic cirrhosis and portal hypertension and the other for persistent diarrhoea

Results

All 15 carcinoid tumours were in the terminal part of the ileum The size of the primary growth varied between 1 cm and 3 cm in the 12 operation specimens available for close examination Multiple primary tumours were present in 3 patients All patients had metastases in the mesenteric lymph nodes and 11 had metastases in the liver

cluded) and ileal carcinoids 66 per cent and 53 per cent, respectively. MOERTEL et coll. (1961) reported a definite relationship between the size of the primary neoplasm and the presence of metastases. Those carcinoids that originate from the appendix seldom produce metastases (MOERTEL et coll. 1968).

Some carcinoid tumours cause a mild form of diarrhoea. Most of them, however, produce no symptoms and are therefore frequently found incidentally at autopsy. Carcinoids may also lead to intestinal obstruction, which is usually secondary to a fibroplastic change in the mesentery and adhesions. Less often the main symptom is haemorrhage. The origin of bleeding may be the tumour itself, ischaemic ileal necrosis due to involvement of mesenteric vessels, or ulceration of the stomach or duodenum (MACDONALD 1956, DARLING & WELCH 1959, GOOD 1963, ANTHONY & DRURY 1970, HORSLEY & BAKER 1970). A malabsorption syndrome with steatorrhoea observed by KOWLESSAR et coll. (1959) was thought to be secondary to local carcinoid metastases causing occlusion of mesenteric veins.

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The angiographic appearances in two cases of ileal carcinoids were described in 1966 (REUTER & BOIJSEN). The characteristic findings seemed to be the radiating arrangement of the vasa recta and the smaller intramesenteric arteries due to retraction of the mesentery, and narrowing or occlusion of mesenteric arteries and veins. Since then these findings have been verified in additional reports (MARSCHAK & LINDNER 1970, BOIJSEN 1971, SHIMKIN et coll. 1971, CLAPS et coll. 1972). The same changes were not observed in one case of a gastric carcinoid (ANDERSEN et coll. 1971).

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b



Fig 1) Preliminary film Two calcifications one in lower quadrant (→) the other in medial part of left lobe of liver (↦) b) Superior mesenteric angiograph arterial phase Main branches of the distal ileal arteries occluded (↦→) More peripheral branches arranged in stellat manner pointing at the site of arterial occlusions and calcifications Ileal artery (→) arising from ileo-colic rtery dilated but occluded t periphery Tortuous collateral arteries in mesentery) Celiac angiography late arterial phase Richly vascularized metastasis with one of the calcifications and several small nodular metastases in left hepatic lobe Autopsy one year later disclosed carcinoid in the distal ileum with metastases to mesentery lymph nodes and liver





b



Fig Woman with mass in lower abdomen) Small bowel examination Distal ileal loops dilated and arranged around a soft tissue mass containing two small calcifications (→) Small bowel constricted (⟼) b) Superior mesenteric angiography arterial phase Vasa recta and the intramesenteric small rterial arcades of terminal ileum infiltrated occluded nd in stellate formation Ileal rtery (⟷) arising f om the ileocolic artery d lated secondary to occlusion f distal branches of the superior mesenteric artery tortuous collateral arteries but no neoplastic essels Proximal part of ileocolic artery and jejunal branches hav slight luminal indentations due rterial infiltration by proximal sp ead t lesion) Venous phase Ileal and l ns occluded th alcifications re of mass Operation Ileal carc noic stri ing bowel lumen small and multiple lymph node metastasc la the adjacent mesenterium



a



b



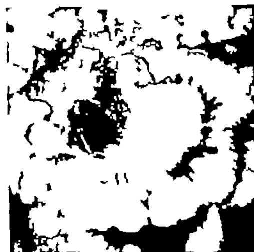
Fig. 3. Woman with ma lower abdomen.) Slightly dilated distal ileal loops ith large and everal smaller masses (→). b) Angiography preliminary film. Two calcification and calcified l mph ode evident.) Superior mesenteric angiography subtraction film. The calcifications were lose to the centre of retraction of the mesentery as observed from th tortuous collateral arteries representing the entre of the tumour with t llate bowel arteries. First part of ileocolic rtery (⟼) in filtrated and its ileal branch (↪) dilated the latter as well as distal branches of superior mesenteric artery occluded. Operation disclosed tumour in the centre of the mesenteric retraction. Some 40 submucosal carcinoid tumours were present in the distal ileum t autopsy four days later.

Conventional films of the abdomen before angiography revealed a soft tissue mass in the right lower abdomen in those patients in whom it was palpable cal cifications were evident in the area and when the preliminary films were com pared with the angiographic ones they proved to lie in the centre of the retracted mesentery or close to it in 7 patients (Figs 1 2 3) The calcifications had not the lobulated appearances observed in healed tuberculous lymphadenitis and were as a rule almost spheric and smooth most varied in size from 4 mm to 6 mm the largest measuring 10 mm by 15 mm One or two calcifications usually occurred in every patient The tumour area of one patient had however four calcifications, each with a diameter of 4 mm The pelvic bones in 5 patients tended to mask and obscure the calcifications (Fig 1) In one patient a me tastatic lesion in the liver was partly calcified (Fig 1)

A barium investigation of the small bowel was negative in 3 of the 12 patients examined in the remaining 9 patients a varying degree and type of dilatation of the distal ileal loops was observed Slight widening combined with moderate mucosal changes and flocculation of barium as occurs in sprue were the only minor bowel abnormalities in 2 patients Dilatation due to obstruction (Fig 2) and bowel wall destruction or retraction of the mesentery (Figs 3 4) were other forms of intestinal widening Marked kinking and deformation of the bowel due to fibroplastic retraction of the mesentery were present in 6 patients these were combined with filling defects or partial strictures caused by the primary or secondary local growth

The primary carcinoid mass was evident but did not produce any obstruction of the bowel or retraction of the mesentery in 2 other patients (Fig 5) Vascular changes at superior mesenteric angiography suggested a carcinoid neoplasm of the ileum in 14 of the 15 patients The most obvious change the arrangement of the vasa recta and the intramesenteric ileal arcades in a radiating manner was present in 10 patients (Figs 1 to 4 and 6) stellate appearances were suggested in 2 pa tients but in another with definite signs of shrinkage of the mesentery (Fig 5) no such appearances were evident A slight tendency towards shrinkage and signs of adhesions were recorded in 2 patients (Fig 7)

Arterial wall infiltration either smooth or irregular was invariably present and ranged from slight narrowing to complet[illegible] occlusion This occurred both at the level of the growth in th[illegible] [illegible]asa recta and in the small intramesenteric as well as the main branches of the [illegible] [illegible]rior mesente[illegible] artery The arterial changes sug gested fibromuscular hyperplasia in one pa[illegible]ent (Fig 4) When present the occlusions were alw[illegible] [illegible] [illegible] in the d[illegible] ileal arteries and the ileal branch arising from the ileo[illegible] art[illegible] was frequently (11 patients) dilated and acting as a collateral artery The sam[illegible] artery [illegible] also often occluded in the tumour area (Figs 1 to 4 and [illegible] [illegible]arr[illegible]ing of those arteries at some distance from the





b

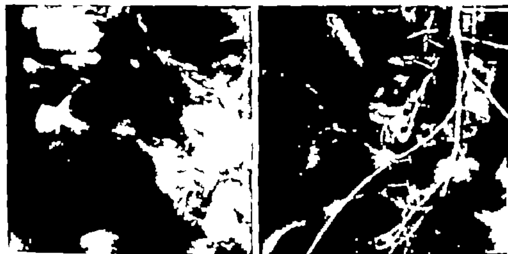


F g 4 Woman ith mass lower bdomen) Marked local dening w th absence of normal muco polypoid lesion (→) present in terminal ileum b) Superior me senteric angiograph arterial phase Distal part of superior mesenteric rtery and its branches infiltrated and tortuous w th p pearances of fibromuscular hyperplasia Col lateral arterial supply from distal jejunal rteries (→) as well as from ileal artery ↔) arising from ileocolic artery Stellat rrangement) Venous phase Occlusions of eins clo to growth enous collaterals over right colic eins (↔) Operation carcinoid and many small satellit tumours inf ltrating the entire bow el wall and ex tending int the mesentery Malignancy in dilated lymphatics

primary growth most frequently occurred in the first part of the ileo-colic artery (Figs 2 3 and 5 to 7) This proximal narrowing was always combined with marked lymph node invasion

Tortuous arteries representing collaterals were observed in 14 patients They bore a certain similarity to tumour vessels but neoplastic neovascularity was never defined

Accumulation of contrast medium within the growth was marked in 3 (Figs 1 4) and slight in 4 patients The area of dense accumulation was approximately 5 cm in diameter revealing that the primary growth and the local metastases



b



Fig 5 Fine needle biopsy suggested metastases from carcinoid 5-HIAA elevated) Probable growth in terminal ileum (→) with the ileocaecal valve swollen and the caecum compressed by an extrinsic mass b) Superior mesenteric angiography Infiltration of ileocolic artery its ileal branch (↦) as well as ileal arteries arising from the superior mesenteric no stellate appearances The tortuous irregular arteries from the main arcade of the terminal ileal artery are probably collateral channels to the poorly demonstrated vasa recta Operation Ileal carcinoid close to ileocaecal valve with local growth) Hepatic metastases

were hypervascular despite the arterial narrowings Eight patients had no accumulations Arteriovenous shunting of medium was never evident Venous occlusions were present in 11 patients an observation based on marked venous collateral circulation or occlusion directly visible in the angiograms (Figs 2 4) In only 2 patients was there direct evidence of patent veins One of these had only slight retraction of the mesentery and some arterial infiltration (Fig 7)

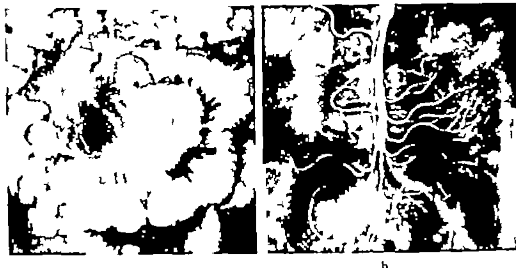




Fig 4 Woman with mass in lower abdomen) Marked local widening w th absence of normal mucosa polypoid lesion (→) present in terminal ileum b) Superior mesenteric angiography arterial phase Distal part of superior mesenteric rtery and its branches infiltrated and tortuous w th p pearances of f bromuscular hyperplasia Collateral rterial supply from distal jej nal rteries (⟼) as well as from ileal rtery ⟼) arising from ileocolic artery St flat arrangement) Venous phase Occlusions of eins close to growth enous collaterals over right colic eins (⟼) Operation carcinoid and many small satellit tumours infiltrating the entire bowel wall and extending into the mesentery Malignancy in dilated lymphatics

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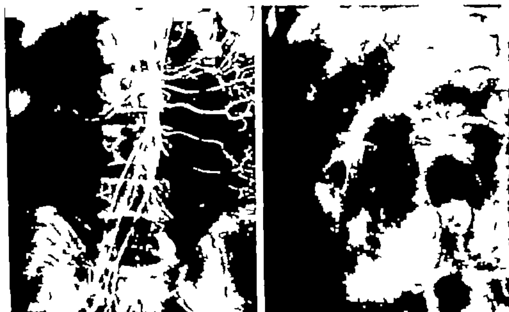


Fig 7 Fine needle biopsy of the liver indicated a carcinoid) S perior mesenteric angiography Infiltrated colic branch of the ileocolic artery (→) Branches of distal part of superior mesenteric artery slightl irregular and displaced by adhesions (⟼) b) Celiac angiography Richly vascularized large hepatic tumour partly supplied by cystic artery (⟷) Operation Ileal carcinoid extending through the bo el wall w th fe lymph node metastases in the ileocaecal me entery and large lesion m the liver ith involvement of the gallbladder

the other had small arterial wall chang s in the vasa recta and the ileal arcades detected first only when th ite of the lesion was known even a retrospective angiographic diagnosis wa not possible The small primary tumour had a diameter of 10 mm with a fe n etastatic nodules in the mesentery It had however produced massive meta tases i the liver (Fig 8)

Hepatic metastases were pr sent in 9 of 12 patients in whom celiac or hepatic angiography was performed I i 7 of these tients these were highly vascularized Tumour vessels were o served in solitary l ge metastases (Figs 1 5 7) dense accumulations of med um wer present in nodular metastases of varying sizes (Figs 1 5 6) Mark d hypervascularization of an enlarged liver and irregular accumulation of med n in th parenchyma were associated when minute metastases were spread hroughout the liver (Fig 8) In 2 patients these were not diagnosed at angiography but at operation were reported to be few and small The 5 HIAA was ported as levated in 10 patients with hepatic metastases Neither angiogr ph nor autop y produced evidence of hepatic metastases despite

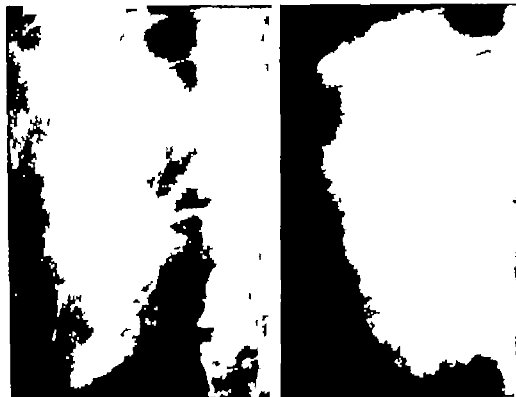


Fig 8 Fine needle biopsy indicated metastases from carcinoid Hepatic angiography Enlarged liver with increased vascularization metastases Operation Ileal carcinoid with massive hepatic metastases

an increase in the 5 HIAA in a patient with widespread metastases in the sternum and retrosternal space

Discussion

Moertel et coll (1961) reported that the radiographic diagnosis of an ileal carcinoid by an examination of the small bowel with barium as the only roentgenologic method was difficult because the growth was a small, deep mucosal lesion and any obstruction was intermittent Hudson & Margulis (1964) however considered in examinations of the small bowel with barium in the 12 patients of their material that the most distinctive feature was the many areas involved The present investigation would appear to indicate that the abnormalities present in the small bowel to a large extent depend on the stage of the

disease Thus at first when the small tumour is still confined to the wall of the bowel no abnormalities can be expected this is also true where no adhesions or fibroplastic changes are present With few exceptions the desmoid change in the mesentery appears first when the neoplasm has extended through the serosa and involved the local lymph nodes Similar alterations in the mesentery with adhesions may be observed in Crohn's disease and are therefore not a definite sign of an ileal carcinoid filling defects or malignant constriction in combination with adhesions and concentric arrangement of dilated bowel loops however suggest such a condition Despite the presence of all these signs the true diagnosis is often made first in retrospect

An additional observation was the presence of one or two small calcifications in the centre of the desmoid change Calcification in an ileal carcinoid was recently observed by NOONAN (1971) who considered it was secondary to necrosis of the tumour ANTHONY & DRURY (1970) however reported elastic vascular sclerosis in 17 of 20 patients with ileal carcinoids that had spread to the mesentery and lymph nodes This was hidden by mesenteric fibrosis and kinking except in one patient in whom a nodular partly calcified mass was present The authors pointed out that the massive elastic tissue proliferation was confined mainly to the adventitia of both arteries and veins although it also extended into the mesentery They had the impression that local spread of the neoplasm into the mesentery was almost invariably associated with elastic sclerosis and also attributed the high affinity of elastic tissue to storage of calcium Calcification observed in the present material always lay in the centre of the sclerotic process Because of their situation over the bony pelvis they may have been present more frequently than they were observed They may be distinguished from lymph node calcifications by their homogeneous dens[illegible]y with smooth spherical or ovoid shapes Phlebolithes have the same appearance b[illegible] their situation is different and carcinoid calcifications are usually larger

The most successful method of diagnosing ileal carcinoids was angiography by which 14 of 15 tumours were demonstrated Our first report on angiography of 2 carcinoid tumours (REUTER & B[illegible] 1966) suggested four signs for both tumours (1) S[illegible]ellat[illegible] arterial appear[illegible] [illegible] ought to be caused by retraction of the mesentery by [illegible] infiltrating neoplasm (2) narrowing of peripheral mesenteric branch[illegible] poor to [illegible] accumulation of contrast medium and (4) no filling c[illegible] [illegible]ining th[illegible] g[illegible] [illegible]

The presen[illegible] [illegible]ation suggests that typical changes caused by ileal carcinoids invad[illegible] [illegible] mesentery ar[illegible] t[illegible] presence of radiating vasa recta and in tramesenter[illegible] [illegible] and narro[illegible] and occlusion of smaller and larger mesenteric arteries [illegible] & REDMAN 19[illegible] described a case of sclerosing fibrinous peritonitis in [illegible] the same radia[illegible] appearance was observed The correct

diagnosis might however have been ileal carcinoid since an operation specimen was not available The present authors checked the course of this patient he eventually died but no autopsy was performed

As mentioned previously a barium examination of the small bowel may reveal changes to suggest Crohn s disease Adhesions may cause stellate appearances of bowel arteries but narrowing or occlusion of the type observed in carcinoid tumours are absent in regional ileitis

The present angiographic observations are in agreement with the histologic findings of ANTHONY & DRURY (1970) These indicated that the elastic sclerosis of mainly the adventitia in distant vessels caused marked narrowing and even obliteration of the arteries in patients with mesenteric metastases The term distant vessels refers to vessels as far as possible from the primary carcinoid tumour in the resected specimen Angiographically this is comparable with the distal ileal arcade and intramesenteric arteries which always were narrowed or occluded Stenosis in the more proximal branches of the superior mesenteric arteries such as in the first part of the ileo colic, middle colic, or jejunal arteries was an additional observation in the angiographic series As already mentioned in the first report these should be regarded as signs of spread of the malignancy along the lymphatics accompanying these vessels

It is of interest that infiltration of the arteries usually does not mean direct malignant invasion of the vessel wall but rather an extension to the lymph nodes which are blocked It has been postulated that serotonin may be responsible for the desmoid change Obviously sclerosis of the vessels occurs first when the regular lymphatic pathways are obstructed The angiographic findings of pancreatic disease may present a similar explanation

The arterial stellate appearances may be absent for two reasons One is that the sclerosis has not markedly changed the mesentery i e local metastases have not developed or are relatively small A second is that the tumour has infiltrated the mesentery and its vessels to such an extent that the smaller branches are poorly demonstrated by angiography The arterial infiltration in one patient was so marked and typically situated in the terminal ileum that no differential diagnostic problems arose (Fig 5) The absence of stellate appearances occurred in 2 further patients who had small lymph node metastases Both had arterial infiltrations and signs of adhesions with some retraction of the mesentery in one of these the vascular infiltration was so limited that a definite diagnosis was withheld There were no other signs indicating the presence of a carcinoid This means that a small primary carcinoid tumour or its first lymph node metastases will fail to be revealed with our present technique of angiography

Newly formed neoplastic vessels—often present in other tumours and especially in those of endocrine origin—were not evident in any of the ileal carcinoids Be

cause of occlusion in the mesenteric arteries abnormal vessels were usually present but these were regarded as collateral arteries even though some might have represented tumour vessels

Accumulation of contrast medium within the small primary tumour was never convincingly demonstrated When present it lay within an area larger than the primary tumour representing local overgrowth to the mesentery The marked vascular sclerosis with narrowing of both arteries and veins may explain the relatively poor vascularization of the ileal carcinoids

Venous stenosis or occlusion was a prominent feature and was obviously always present with marked overgrowth of the tumour to the mesentery Arteriovenous shunting is observed in most neoplasms arising from the bowel as well as in inflammatory disease (BOIJSEN & REUTER 1966) Our previous report recorded no evidence of shunting in carcinoids an observation verified in the present series The main reason for its absence could be the occlusion of the mesenteric veins although it was also not observed in 2 patients in whom the veins were patent

Venous stasis probably caused the symptoms of sprue or Crohn s disease in this material as well as in other reports The faecal fat in 2 patients was measured and proved to be elevated The malabsorption syndrome with steatorrhoea in carcinoid tumour has been reported previously and regarded as secondary to venous occlusion (KOWLESSAR et coll 1959) In both patients in this material peripheral mesenteric arteries and veins were occluded but not to any greater extent than in other patients without an obvious sprue syndrome although in these the faecal fat was not measured The importance of examining the mesenteric vascular system in various kinds of malabsorption has been stressed (BOIJSEN & TYLEN 1972) the present authors came upon a carcinoid tumour unexpectedly in one patient with diarrhoea as the only symptom The absence of early venous filling and occlusion of veins are important diagnostic features in the differentiation of carcinoid tumours from regional enteritis Active Crohn s disease always signifies shunting and in an inactive phase there may be even hypovascularity Even if adhesions and moderate desmoid changes of the mesentery exist in Crohn s disease arterial wall infiltration would be unlikely

Other neoplasms of the gastrointestinal tract may cause angiographic changes that should be correlated to those of carcinoids Reticulum cell sarcoma (LUNDERQUIST et coll 1971) and mesenchymal growths (BOIJSEN & REUTER 1966 KAUDE et coll 1972) will not have the angiographic characteristics of carcinoid tumours Adenocarcinoma and metastases may cause narrowing of mesenteric arteries but probably not the marked desmoid change observed in carcinoids

Metastases from alimentary endocrine tumours are richly vascularized as are hepatic metastases from ileal carcinoids Because of this characteristic quite small

metastases may be observed (LUDIN et coll 1966) This was confirmed in the present series although it was not demonstrated angiographically in 2 of 7 patients The metastases in these 2 patients were reported to be small few in number and located near the surface of the liver Thus, the metastases appear to possess a higher vascularity than the original growth in the bowel This is at variance with what has been noted in other neoplasms where the metastases usually have the same type of vascularization as the primary growth The explanation for this may be the previously mentioned fact that the blood supply of the primary lesion is markedly changed by vascular infiltration

The present series indicates that hepatic metastases may vary from a few huge nodular masses to small nodules There is also a third variety of diffuse infiltrating growth All types have one feature in common they possess a rich vascular supply that will appear as newly formed tumour vessels if the metastases have reached a certain size The hypervascularization will otherwise be observed as a dense accumulation of contrast medium Small nodular metastases in the liver will be revealed only if numerous

SUMMARY

I material f 15 patients with ileal carcinoid tumours calcifications were demonstrated 7 cases Angiography 14 f th cases revealed narrow ng or occlusion f the superior mesenteric artery The angiographic diagnosis cannot be made until the ileal carcinoid has extended t the mesentery and infiltrated the lymph nodes Metastases to the liver are alw y richly ascularized and were present n 7 of 9 patients

ZUSAMMENFASSUNG

In einem Materi l on 15 Patienten mit om Ileum ausgehenden karzinoiden Tumoren wurden 7 Falle mit Kalzifikationen beobachtet D e Angiographie ergab in 14 dieser Falle eine Verengerung oder einen Verschluss der Arteria mesenterica superior Die angio graphische Diagnose kann nicht gestellt werden bevor das Carcinoid das Mesent rium er reicht und di Lymphknoten i filtriert hat Lebermetastasen sind stets reichlich vaskularisiert und fanden sich bei 7 on 9 Patienten

RÉSUMÉ

Sur une seri de 15 malades tteints de tumeurs carcinoides d grele les auteurs ont ob serv des calcifications dans 7 cas L angiographi chez 14 malades a toujours montre un retrecissement ou un obstruction d l arter mesenterique superieure Le diagnostic angio graphique peut pas etre fait a ant que le carcinoide d grele se soit etendu au mesentere et ait infiltre les ganglions lymphatiques Les metastases hepatiques sont toujours richement asculariseee et existaient chez 7 malades sur 9

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ORGANIC TRICUSPID VALVULAR INSUFFICIENCY IN CHILDREN

J T MALLAMO and E CARLSSON

Clinically significant organic tricuspid valvular disease unrelated to other cardiovascular abnormalities is rare (GLANCY et coll 1969) and its many causes include congenital anomalies carcinoid heart disease trauma endomyocardial fibrosis of the right ventricle and infective endocarditis (AHN & SEGAL 1966 CHERUBIN et coll 1968 GLANCY et coll 1969 OSBORN et coll 1964) The functional form of tricuspid insufficiency supposedly related to hypertrophy and later dilatation of the right ventricle with subsequent dilatation of the tricuspid annulus is uncommon when the heart is in sinus rhythm No cases of rheumatic heart disease involving only the tricuspid valve with or without insufficiency have been reported

The mo t common causes of congenital tricuspid insufficiency are defects in the valve assoc t d ith Ebs ein s malformation and an endocardial cushion defect wi l i e KINCAID et coll 1962) a less common rea on is congenita r 1 d ie t dinae that prevent closures of the apparently normal en more ra is fenestration of the tricuspid valve this is in variably vith a ricular septal defect and has not otherwi e been reported

Submitt t on 4 De mber 1972

Traumatic tricuspid insufficiency falls into two categories (1) ruptured papillary muscle and (2) ruptured chordae tendinae with or without the valve (MORGAN & FORKER 1971) Although most of these lesions are a result of mechanical injury and myocardial infarction some have been reported to occur secondarily to syphilis, myocardial abscesses and polyarteritis nodosa (OSBORN et coll 1964) Symptoms and signs are frequently absent or mild and the onset may be delayed especially in group 2 If the papillary muscles are ruptured the symptoms and signs are more acute (MORGAN & FORKER 1971)

Isolated right sided vegetations were evident at autopsy in about 5 per cent of cases with infective endocarditis (BAIN et coll 1958 SHANKAR et coll 1967 WILSON 1963) Most of these had no underlying heart disease the vegetations appearing on previously normal valves (GLANCY et coll 1969) Bacterial and mycotic endocarditis is a serious complication in drug addiction (CHERUBIN et coll 1968) CHERUBIN et coll reported sole tricuspid valve changes in 9 per cent and bilateral multivalvular endocarditis involving the tricuspid valve in another 9 per cent of such cases As expected, the aortic and mitral valves were those most commonly affected (CHERUBIN et coll 1968) Staphylococcus was the major organism isolated in CHERUBIN's series of drug addicts admitted to hospital

Right sided differs from left sided endocarditis in many respects Septic pulmonary emboli pneumonitis and abscesses are characteristic of tricuspid valve endocarditis Systemic arterial emboli and various forms of glomerulonephritis which are more common with left sided valvulitis, however occur with isolated tricuspid lesions With the exception of abscesses and pyelonephritis, renal lesions are rarely associated with right sided endocarditis Protein losing enteropathy has also been linked with tricuspid insufficiency (STROBER et coll 1968)

The purpose of this communication is to report 2 rare cases of organic tricuspid valve insufficiency in small children (CHERUBIN et coll 1968) in one of which the degree of regurgitation was measured with the cineradiographic methods available In one of the cases the posterior tricuspid valve leaflet was fenestrated in combination with valvular and infundibular pulmonary stenosis while in the other the tricuspid valvular insufficiency (caused by staphylococcal valvulitis) was isolated

Case reports

Case I Female a Caucasian, aged 34 months was born at 8 months weight 2 5 kg No reports of serious illness or family history of congenital heart disease A cardiac murmur was present She did well until 2 years f ge when progressing cyanosis brought her to the hospital Her development appeared satisfactory except for a 50 per cent reduction in exercise toleranc At 30 months she could rest without squatting when fatigued ECG Right bundle branch block and right ventricular hypertrophy Chest roentgenography



Fig 1 Ca 1 Chest p Signi ficantl enlarged right trium nd right entricle small middle pulmonary artery ith decreased pulmonary a cularity

Marked cardiac enlargement w th reduced pulmonary asculari No neck ein distension evident pex beat in the 5th intercostal spac at the left midcla icular line A moderat systolic thrill was present over the left border of the sternum with a entricular thrust to th right f the xiphoid process A grade 4/6 harsh systolic murmur was heard over the lower left border of the sternum and grade 3/6 blowing systolic murmur was present at the second left intercostal space as ociated ith a grade 2/6 systolic murm The liver as palpable 2 cm below the right costal margin Moderat cyanosis of th finger nd toe nails with purplish discoloration of the tips the digits without cl bbing was noted At 34 months single chest film (Fig 1) revealed an enlarged right trium and right entricl and a small main pulmonary artery with decreased pulmonary vascularity At cardiac catheteriza tion a moderat right t left shunt t the atrial level was present although the mean pressures were equalized indicating larg communication between the atria Right entricular and diast l pressures ere not ele ated and the right entricular systolic pressure (110/7) was about 20 mm Hg higher than that f the left entricle (90/7) w th triangular configura ion represent ng an ntricular septum Th pulmonary and systemic vascular an es were normal Cine ardioangiography demonstrated that the right entricl was h pertrophied with large amount f contrast medium egurgitating into and fillin enlarged righ atrium (Fig 2) A systolic jet (Fig 3) suggested a defect in th l aflet of th tricuspid alv The right entricular outflow as hypertrophied d restricted (Fig) Th thickened pulmonary alv as dom shaped in entricular sy he main pulm ary artery as dilated Cardioangiography suggested alvular and bular pulmonary stenosis and tricuspid insuffic ency Operation revealed markedly d right atrium ri ht atrial appendage and a large right entric l The coronary rt ere normal There was harsh thrill over th main pulmonary artery central or of th dome shaped pu monary valv measured 2 mm in diameter Longitudinal lm onary arteriotomy with an incision int the pulmonary alv completel relieved the ruction A regurgitant jet from th tricuspid alv was palpable in the right



Fig



Fig 3

Fig Ca 1 Cineangiocardiogram Right entricle enlarged nd hypertrophied enlarged gh trium

Fig 3 Case 1 The contrast medium has regurgitated from the right entricle to the right trium (→) during entricular systole indicating defect in the lateral leaflet of the tricu pid alv (confirmed t operation)

trium during entricular syst le A rounded fenestration 1 cm in diameter noted in tl small lateral leaflet of th tricuspid valve as well as a patent foramen ovale ere closed On completion f the operation the tricuspid val e was competent The pressures in the right side of the heart wer right atrium 6 mm right entricular body 42 mm systolic righ t entricular infundibulum 35 mm and main pulmonary artery 25 mm systolic The post operativ course was unev entf l and the patient was discharged without medication

Case 2 Mal Caucasian aged 42 months normal pregnancy w th a weight t birth of 3 6 kg The neonatal period and early infancy were also normal with no history f cyanosi cardia murmur respiratory diff culty or family heart disease Th child was well until he was 30 months of age when he was dmitted with a short history of temperature of up to 40 C Blood culture Staphylococcal aureus coagulase positive A mild pustular ra h was treated w th penicillin 6 million units intravenously Staph lococcal pneumonia developed and progressed t bilateral empyema requiring multipl thoracenteses and chest tubes An initial chest film at 30 months had been normal (Fig 4) He subsequently developed congestive heart failure with progressiv cardiomegaly Treatment with digitalis was com menced ECG T wave inversion which reverted to normal after 6 weeks A heart murmur the character of which was not described was first noted along with gallop rhythm The patient was discharged on digitalis after 6 weeks f intra enous antibiotics Roentgen ography of th chest at 38 months recorded significant cardia enlargement with a prominent right atrium but no pulmonary oedema (Fig 4 b)

When the patient was 43 months ld he was admitted to th University of California San Francisco for cardia catheterization N neck vein distension evident Bilateral prominent pulsations were noted in the supraclavicular areas A diffuse left parasternal impulse was thought to represent the right entricular impulse no left entricular impulse



Fig 4) Case 2 Chest p Normal th no cardiac enlargement or signs of congestive heart failure b) Eight months later Significant cardiac enlargement with prominent right atrium but no evidence of pulmonary oedema

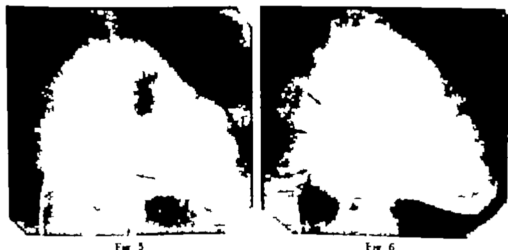


Fig 5 Fig 6

Fig Ca Cineangiocardiogram Tricuspid l normal in position Th contrast medium filled the larg trab culated righ en le nd egurgitated to the enlarged right triu

Fig 6 Case 2 Ventricular diastole Th de f right entricular enlargement is indica l by arrow

present A p mment thrill was noted ong e lower left border f the sternu Th heart ound m ffled There was l n f S1 and S2 with the aortic nd pulmonary component f equal intensity but not ios with respiration N S3 was evident A grade 3/6 somewh harsh long syst lic murmur f platea shape was best heard long th lower left border he sternum radiating th right axilla A grade 2/6 midsystolic murmur


Fig 7


Fig 8

Fig 7 Case 2 The left entricle in diastole small compared to the enlarged right entricle
Fig 8 Case The small left entricle displaced posteriorly by the enlarged right entricl

was present t the upper right and l ft borders of the sternum and radiating along th pulmonary outflow tract with grad 1/6 early diast lic rumbl on the left side The liver was palpable 2 cm below the right costal margin no clubbing or cyano is present ECG Right bundle branch block Cardiomegaly with prominent right trium but without signs f congestiv heart failure in a conventional chest f lm

Cardia catheterization enabled the blood oxygen saturations to be compared these were normal in ll chambers indicating no l ft t right shunt at any level th ascending aortic oxygen saturation and tension were normal eliminating a right t left shunt Pulmonary and systemic flows were equal and normal The mean pressure in the right atrium and superior and inferior ena cava was slightly levated with a dominant V w compatibl with tricuspid insufficiency The right atrial pressure was sometimes normal but domi nant V wav was nvariably present The right ventricular pressure was at its upper normal limits with slightly elevated end diastolic pressure (32/9) The mean and phasic pressures f the main pulmonary artery were also normal the left ventricula pressure was not affected An lectrocathode placed in th body f th right entricl with simultaneous pressures and intracardiac ECG measurements ruled out Ebstein anomaly Cineangiography revealed the tricuspid alv t be in normal position with a large trabeculated right entricle and f lling f a dilated right entricular outflow tract and a large right atrium during entricular systole (Fig 5) Th right entricl was markedly enlarged diastole (Fig 6) The pulmonary valve was competent The left compared t th right entricl was small (Fig 7) and displaced posterio ly by th enlarged right entricl (Fig 8) Ventricular volume measurements were obtained from the right and left entricular cineangiogram (T ble)

Tabl

I entricular volume measurement

	Right entricle	Left entricl
End-diastolic lume	31 3 ml m	15 3 ml/m
End systolic olume	21 6 ml m	4 4 ml m
Stroke olume	36 ml/m	10 9 ml m
Ri ht entricular stroke olume / Left entricular stroke olume	= 3 3	
Tricuspid regurgitant flow	= 3 3 ml/beat	

Cardioangiography indicated tricu pid alv insuff ciency The ho pital course was un eventful the patient was discharged nd since then has remained in congestiv heart failure

Comments

The diagnosis of tricuspid insufficiency may at times present difficulties especially in children The typical signs of the lesion i e positive systolic pulsa tions of the neck veins pansystolic murmur frequently accentuated on deep inspiration, cyanosis and hepatomegaly usually although not always indicate gross insufficiency Less severe regurgitation may be present without the usual signs of the condition (AHN & SEGAL 1966)

The characteristic pansystolic murmur may not be audible even in patients with gross regurgitation and large V waves in the neck The clinical course of right sided heart failure usually is slowly deteriorating Although this may be true for many adults with slight or moderate tri uspid insufficiency sudden death is more common especially in children with gross lesions (AHN & SEGAL 1966 KELLER et coll 1970) AHN stated that the overall prognosis in isolated tricuspid valve insufficiency was much worse than previously believed with 16 5 years as the average survival age of pat nts with congenital tricuspid insufficiency Although the diagnosis of tricusp val e ufficiency may be made at cardiac catheterization by means of indicator ut on and right atrial pressure curves false positiv indicate the need for ight ntricular cardioangiography

Cardioangiography will also perm qu ntitation of the degree of tricuspid valve regu gitation with the methoc de cribed for right and left ventricular volume me surements by GOERKE et coll (1967) and CARLSSON et coll (1971) The differ nce in stroke volume be ween the right and the left ventricles constitute he regurgitant flow per art beat This approach is valid as long

as there is no shunt or additional valvular insufficiency of the right ventricle. The ventricular septum in Case 2 was intact at cardiac catheterization and cardioangiography. No signs existed of pulmonary valve insufficiency. However a separate injection of contrast medium into the main pulmonary artery to rule out this possibility was not made. The injection of medium into the right ventricle caused ectopic beats so that the stroke volumes measured on the right and the left sides were not directly comparable. It has been demonstrated earlier that temporary volume discrepancies between the two ventricles may be allowed for if the effective diastolic filling time of the two beats be calculated from the films and the ratio between the two time periods be presumed to be one in the disturbed heart. Accurate stroke volume comparisons in a group of patients with no shunts or valvular insufficiencies were obtained by this method (CARLSSON et coll 1971). It is possible that the diastolic filling time ratio is different with large variations in stroke volume between the two ventricles. The largest ventricle would then be expected to have the longest filling time presumably accomplished by a reduction in the length of the diastasis. If a difference in filling time indeed exists with a longer time for the largest ventricle this would tend to increase the difference calculated in stroke volumes. The measurements now presented would therefore indicate a minimum difference and if anything an underestimation of the degree of tricuspid valve insufficiency. Even without actual measurement cardioangiography will allow a semiquantitative estimate by observation alone. Quantitation should always be attempted in children as the degree of regurgitation may vary considerably and because the severe forms are associated with a high mortality rate (AHN & SEGAL 1966).

Some authors (CAIRNS et coll 1968, GOULD et coll 1965, PARKER et coll 1967) have concluded that contrast medium regurgitation is usually absent with atrial fibrillation but may be induced by catheter interference with the tricuspid valve. BOOREN et coll have reported that the tricuspid valve closure is not impaired by the presence of the catheter per se in the tricuspid ostium with normal sinus rhythm. If extrasystoles be produced by the injection of medium the resultant valve insufficiency may usually be identified as accidental (BOOREN et coll 1972).

The ventricular volume measurements in Case 2 indicate a marked degree of tricuspid valvular regurgitation (approximately 23 ml per heart beat with a stroke volume of 36.2 ml, see Table). The ejection fractions of the ventricles are equal and within normal limits. The left ventricular volume is considerably smaller than the normal value for a 3.5 year old child indicating interference with the diastolic filling by the enlarged right ventricle. GRAHAM et coll stated that the normal value of the left ventricular enddiastolic volume is 17 ± 2 ml/m body surface area in children over 2 years of age (GRAHAM et coll 1971) while

such volume in children under 2 years is 42 ± 1 ml/m These authors suggested that the discrepancy is probably caused by a difference in heart rate The group of patients over 2 years had an average heart rate of 99 ± 15 while the average mean rate of those under this was 14? ± 14 The heart rate of the present patients was 120 immediately before and during the cardioangiography A left ventricular end diastolic volume of 15 3 ml is still much below normal GRAHAM however stated in a later report (1972) GRAHAM et coll (1972) that patients with a large right ventricle may have a reduction of as much as 50 per cent in the left ventricular end diastolic volume which would mean approximately 20 ml In view of this the volume figure now given would appear reasonable

Acknowledgements

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SUMMARY

Two cases of organic tricuspid alve insufficiency in children are reported The signif cance f quantitation is stressed and cineradiographic method for measurement of the regurgitant flow pplied in one f th cases is described and discussed

ZUSAMMENFASSUNG

Zwei Fall einer organischen Trikuspidalklappeninsuffizienz bei Kindern werden be schrieben D Bedeutung der quantitativen Beurteilung wird hervorgehoben und eine Serien rontgen Methode zur Messung des Ruckflusses ie sie bei einem der Fall erwendet wurde beschrieben und diskutiert

RÉSUMÉ

Présentation de deux cas d in ffisance organ que de la valvule tricuspid chez des enfants Les auteurs insistent sur l im d im d quantitative et decrivent et discutent une method cine radiographiq pou la mes du débit de regurgitation

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FILM QUALITY IN MAMMARY RADIOGRAPHY

E DEICHGRABER S REICHMANN and M BUREN

Reference to the literature for some help as to the best film for roentgenography of the female breast soon discloses that almost every type of film has its advocate EGAN (1964) and EGAN & FENN (1968) recommended low sensitivity industrial non screen films which was also approved by MINAGI et coll (1968) and YOUNG (1969) At the other end of the sensitivity spectrum lies the technique described by STRAX & OPPENHEIM (1968) with an image intensifier and a 70 mm camera GERSHON COHEN et coll (1965) pioneers of mammary radiography had for long stubbornly criticized the use of low sensitivity industrial film implying that this ha a relatively poor rendering of contrast as compared with the usual medical no s reen film Furthermore they considered the dose to the patient to be too hi However when they replaced the tungsten target roentgen tube ith one a molybdenum target, which gives higher doses owing to soft radiatio KA & REISS 1968) they suddenly came to recommend the F type A ustrial film accepting a dose increase from about 1 rad/expo about d/exposure (GERSHON COHEN et coll 1970) T volte face d choice film was left unexplained High sensitivity industrial film bee recom nded by PRICE & BUTLER (1969) and RICHM ND (1969) th ai since they did not compress the breast could not use films of ivity

Submitted ... 22 January 1973

Most authors agree that non screen film appears to be best for mammary radiography One problem with this type of film exists however namely the achievement of proper processing Such film contains much more silver than ordinary roentgen film by reason of the thicker emulsion This requires more time for the diffusion of the processing chemicals the fixing and the rinsing are especially difficult tending to make long process times necessary (LUNDH 1972) Industrial film contains large amounts of silver and consequently the process time is also relatively long so far optimal development of such film has been achieved only by means of tank processing This has been a serious drawback and has given rise to attempts at using film adapted for shorter processing Thus a non screen film has recently been introduced for radiography of the breast and processing in 90 seconds This film was tested and approved by BARTH et coll (1972) Likewise a Medichrome film (Agfa Gevaert) intended for intensifying screens has been used without screens by FLOAZZOLA (1971) This film too was regarded as being of superior quality However if a non screen film contains only submaximal amounts of the recording medium i e silver it may also be expected to afford only submaximal information Thus if the silver content be low so as to make the film processing easy then the image quality may also be down

Progress has lately been made in the composition of processing reagents Thus a new combination of chemicals has made possible a processing time of 6 minutes for industrial non screen film in an ordinary roll machine

The present investigation was aimed at the image quality obtainable with a 90 second film for examining the breast in comparison with an industrial film of equal sensitivity the latter being processed in 6 minutes Consideration was also given to whether tank development will increase image quality in either of the two film types Furthermore an attempt was made to establish the optimal sensitivity of the film type considered preferable

An emulsion with a high silver content—Agfa Gevaert Mamoray 2—was compared with an emulsion for 90-second processing Kodak PE 4006 in order to decide which type of emulsion and development would produce most information for a given dose of radiation Since the emulsion with a high silver content gave better recordings such emulsions of varying sensitivity were compared The investigation was carried out in several steps each based on the earlier results Each test together with its results will now be described before the next is presented

The characteristic curves of the two types of emulsion when developed in a machine and a tank were examined The chemicals in all types of processing are presented in Table 1 the temperature was in accordance with the recommendations of the manufacturer The Mamoray film was machine developed with

Table 1

Survey of the different kinds of processing of the two films tested. All chemicals manufactured by Agfa Gevaert

Film	Tank process	6 min roll machine	90 [illegible] roll machine
PE 4006	dev G 150 fix G 334		dev G 138 fix G 334
Mamoray 2	dev G 150 fix G 334	dev G 172 fix G 372	

a processing time of 6 minutes, this length of time being necessary for proper fixing and rinsing. The roll machine used in this test, as well as in the 90 second processing, was a Pakorol. The films were exposed in a stepwise manner so that the characteristic curves could be obtained after being subjected to densitometry. The following results emerged. Both films underwent a slight decrease in sensitivity when developed in a roll machine as compared with optimal tank development. The form of the characteristic curve did not change appreciably. When the shapes of the curves for the two film types were compared one important difference was evident. The Mamoray film had a curve displaying increasing inclination up to density $D = 3$ (the highest value of the densitometer), while the curve of the other film began to decrease in inclination at $D = 2.5$. This was interpreted as an indication of a lower silver content in the second emulsion than in the first. When the absolute sensitivities of the two films were compared, it became apparent that the PE 4006 emulsion had a slightly lower sensitivity.

As a difference in the shape of the characteristic curves of the two films existed above $D = 2.5$, an attempt was made to discover the optimal density level for roentgenography of the breast. Slices of breast tissue were exposed in a Siemens Mammomat equipped with a molybdenum target and filter at a tube potential of 28 kV. Different mAs settings were used so that varying densities were obtained in the Mamoray 2 film which was developed in a roll machine as described above. A background density of $D = 2.0$ proved most [illegible]able. Higher densities caused trouble in inspection even if strong ligh[illegible]used, whereas lower densities made for less image contrast. It thus app[illegible]d that roentgenography of the breast should preferably be performed at a [illegible] level at which the two films display similar characteristic curves. The quality [illegible] film is only partially indicated however by the characteristic curv[illegible]. Qu[illegible] mottle is also important. This factor reflects how many of the photo[illegible]

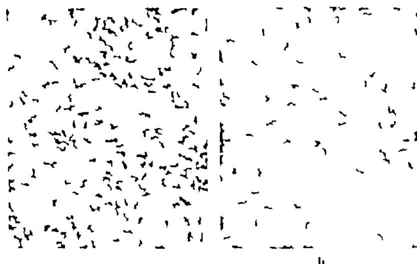


Fig 1 The same magnification of areas of identical density in) the 90 second film nd b) the industrial film The gra niness n creased in ( )

the film are really absorbed so that their effect is incorporated into the final image Most photons are not absorbed although different films may take up differently large fractions of a given roentgen dose thus displaying varying degrees of efficiency A film of high efficiency makes for low quantum mottle and will have a higher resolving power than one with the same sensitivity but lower efficiency

The efficiency of a film or a screen film combination depends on the fraction of photons absorbed from the incident radiation This absorptive capacity is determined with non screen film by the silver content Thus, emulsions with a high silver content generally produce images with a lower quantum mottle than those of lower silver content while yet of the same sensitivity

The two emulsions compared in the present investigation were found to possess roughly the same sensitivity but a difference in the characteristic curves of the films indicated a lower silver content in the 90 second emulsion The next task was to assess whether any difference existed in quantum mottle in comparable images of the two films The first approach to this problem was based on photomicrography of areas of the same density in the two films It appeared that the grain in the 90 second film was coarser (Fig 1) This is in accordance with the assumption of a difference in silver content and quantum mottle If fewer photons be assumed to produce a given density then each silver grain pre cipitated must be larger since each photon can give rise only to one silver grain



Fig 2 The same detail from) a 90-second film and b) an industrial f lm th high silver content The copy in) as obtained after exact superpositioning of the films in ( ) and (b) A marked difference in information is evident Magnification × 2

(BACKSTROM & LUNDH 1959) Now the question arises whether the differences demonstrated in quantum mottle are of any importance The only answer to this problem must b~ based on clinical roentgen examinations of mammae To obtain completely comparable images the two films were placed in one envelope with the somewhat less sensitive 90 second film *nearest to the roentgen tube* the absorption of this film produced the same density in the two films in spite of the differences in sensitivity All exposures were made with the Mammomat and the films developed in roll machines as described A total of 22 pairs of roentgenograms were examined in this way with *uniform results Inspected* at a distance the pair seemed to be identical At high densities however such as in the periphery of the breast image the blackening was lower in the 90 second film owing to the difference in the characteristic curves On closer scrutiny even without magnification this film appeared to possess *less contrast* even in the central area of the breast, not obvious in the ordinary way Detail of k contrast was thus much more apparent in the film with a high silver cont (Fig 2 a b) Likewise microcalcifications were more readily recognizal such The 90 second film often left doubt whether small points were c u calcifications or not There was no apparent difference in unsharpness

Having established that only emulsions with a high silver conten orth testing in roentgenograph of the breast the question of the optim al degree of sensitivity had to be examined It was assumed that only a small differ nce exi t



Fig 3 The same detail of a breast phantom recorded in industrial film of high silver content with different sensitivities Three nylon threads (diameters 1 0 0 75 and 0 5 mm) are situated in a layer of vegetable oil (height 3 cm) The film sensitivities (cf Table) a) 2 b) 100 c) 170 d) 3 5 and e) 650 The image quality rapidly deteriorates when the sensitivity rises from 100 to 170

between non screen films of identical sensitivity offered by different manufactures as long as these possess a high silver content one grain is of course always obtained from one absorbed photon A series of films of high silver content and a relative sensitivity ranging from 25 to 650 was tested it being assumed that the sensitivity of Mamoray 2 is 100 These films enabled roentgenograms of similar density of breast phantoms to be made at two tube potentials of the Mammomat i e 28 and 35 kV The phantoms were similarly constructed but represented different masses of soft tissue They consisted of quadrangular thin walled plastic bottles more or less filled with vegetable oil in which were nylon threads of 0 25 mm to 1 mm diameter Minute calcifications were embedded in epoxy resin within the bottles The thickness of the oil layer amounted to 1 cm 3 cm 5 cm and 7 cm the bases of the bottles measured 9 cm × 15 cm All films were tank developed since those of the highest sensitivity proved to be extremely sensitive to the pressure exerted by the rolls of the developing machine

The results of this investigation were uniform (Fig 3) The quantum mottle at sensitivity 100 and below could not be discerned without a magnifying glass The reproduction thus appeared to be smooth and grain free With the naked eye no difference in information capacity was evident between sensitivities of 100 and 25 magnification revealed differences however so that sensitivity 25 gave a higher resolution to make lower contrast visible With a film sensitivity over 100 the quantum mottle became increasingly apparent to the naked eye The most disturbing increase occurred between sensitivities 325 and 650 In passing from

Table 2

Survey of different films used in comparison between different sensitivities in emulsions of high silver content

Manufacturer	Film type	Relative sensitivity
Agfa Gevaert	Structurix D 4	5
Agfa Gevaert	Mamoray 2 (= Structurix D 7)	100
Kodak	Crystallex	170
Kodak	Industrex	325
Kodak	Kodirex	650

100 to 170 only an insignificant increase in quantum mottle appeared. The interesting observation was that quality rapidly deteriorated along with the increase in visibility of the quantum mottle. The sensitivity region between 100 and 170 examined without magnification appeared to combine the highest possible information with the lowest roentgen dose. Less sensitive films seemed to require magnification to be differentiated from optimal films; more sensitive films generally contained less information.

One situation arose in which a sensitivity higher than 170 proved to be justified. When the phantom thickness increased from 5 cm to 7 cm, image quality suffered a remarkable decrease. It appeared that sensitivity 325 differed so little from lower sensitivities that it may well be recommended for the examination of thick breasts. Even in this situation, however, the highest sensitivity of 650 appeared to impair the image quality to such a degree as to preclude its use altogether.

Discussion

The present investigation of non-screen film in radiography of the female breast has disclosed certain important facts that have not been universally recognized before. The first of these was that a film with a high silver content is always to be preferred to one of equal sensitivity but with a lower silver content. The direct comparison between two emulsions with different silver contents made it clear that the difference lies in the higher quantum mottle of the emulsion with a lower content. The comparison between emulsions having high silver contents but differing in sensitivity likewise proved the quantum mottle to be of great significance for image quality. Certain films should thus not be recommended for this examination technique owing to their low silver content, namely the 90 second film intended for mammary radiography, the medical non

screen film for roll machine processing and the Medichrome film meant for use with screens although applied to mammary roentgenography without screens These films can be replaced by industrial film of the same sensitivity and high silver content having the capacity to absorb more photons and thus produce more information BARTH et coll (1972) were unable to detect any differences between a 90 second film and an industrial film of high silver content However the two films were not placed in the same envelope but were corrected for comparison by varying the exposure quantum mottle was ignored Another interesting result was the discovery that the sensitivity of a non screen film of high silver content lies within narrow limits for the achievement of the best quality without unduly high roentgen doses The sensitivity should not be set below 100 in the terms of this investigation (Table 2) unless secondary magnification be contemplated only seldom where the breast is thick, is it advantageous to raise the sensitivity up to 325 The optimum seems to be at 100 to 170 It deserves mentioning that the Kodak films Crystallex and Industrex may both be processed with the new chemicals for 6 minutes As regards the Industrex film with its high sensitivity of 325 the utmost care should be taken to keep the rolls of the processing machine clean and even to avoid wet pressure marks

A good example of how films of different sensitivity should not be compared as to recording capacity was presented by PRICE & BUTLER (1970) They put two industrial films of different sensitivity into the same envelope exposing them simultaneously They appeared surprised to find that the film with the higher sensitivity gave a recording that was as good as that of the other film they recommended the use of high sensitivity films The authors did not realize that the two films gave recordings with the same quantum mottle since they were exposed to about the same dose and had the same absorptive capacity The signal/noise ratio was thus the same in both recordings, in spite of the difference in film sensitivity What they did prove however was the fact that this ratio is of the utmost importance while the other characteristics of non screen film of high silver content are of limited significance

Radiography of the breast with a molybdenum target and filter and films considered optimal in quality unfortunately leads to high roentgen doses to the patient It would appear that if the breast has an absorption factor of 5 cm of water the dose will be between 10 and 20 rad per exposure This price can be paid only in situations where disease is probable it cannot be accepted for health controls other than possibly of the aged This hazard has been ignored to a surprising degree by earlier authors Much ingenuity has been applied to the question whether the molybdenum anode really possesses an advantage over its tungsten counterpart (MIKA & REISS 1968 JAEGER 1969 HACH 1972 KYSER 1972) The rendering of optimal contrast of the image regardless of roentgen

dose appears however always to have constituted the primary aim The data available from the investigations mentioned indicate that the molybdenum target will give a higher contrast than the tungsten anode provided that the absorption of the breast does not amount to more than 4 to 5 cm of water The present authors have been able to confirm this by means of phantom examinations of their own However the total dose and consequently the quantum mottle have not been incorporated into the calculations so it is not known which technique gives the better information for the lowest roentgen dose to the patient If this problem is to be analysed the minimum number of photons necessary to produce a noise free recording should first be recognised An attempt should then be made to establish a technique including target material and filtering that can make this number accessible to the film so as to supply the best contrast in the representation and the least unnecessary absorption within the patient The present investigation indicates the optimal non screen film sensitivity that can be obtained If the number of photons required to produce the image with such a film were known access would be gained to important basic information of a kind that would open new ways in the search for a good low dose technique for mammary radiography

One major reason underlying the generation of the high radiation doses in radiography of the breast lies in the low efficiency of the film regardless of whether it has a high silver content or not A striking example of how much further information may be extracted from a given roentgen dose if the efficiency of the film be increased appears in Fig 2 c Here two films have been placed one on top of the other producing extreme density a copy of this double roentgenogram exhibited a high degree of contrast If there were films of such efficiency although perhaps still not giving the high density of the two combined films the extremely soft roentgen rays of the molybdenum target might be superfluous It must be emphasized that too little interest has been given to the film problem in the examination procedure under discussion Today only films and screens developed for radiography at higher tube potentials are used Special films appear to be as important as special roentgen tubes for this type of roentgen examination At present however the industrial roentgen films seem to give the best recording

One important practical question in the use of industrial films concerns the usefulness of the new chemicals for the processing of other types of roentgen film A roll machine cannot be left working all the time at 6 minute processing unless mammary radiographies are constantly being performed It should be possible to employ the machine at a shorter processing time when necessary Since these reversions must be rapid it should be a matter of the speed of the driver only and not of the temperature It has been found possible to use the Pakorol alternatively

for 2 5 and 6 minute processing times with the developer temperature at 30 75 C The shorter processing is reserved for the usual screen films (Agfa Gevaert Curix RP 1) and medical non screen film (Agfa Gevaert Osray M) With the temperature raised to 35 C, 90 second processing may be carried out for screen films If the Mamoray film is then developed at 6 minute processing time slight basal fog appears but is not disturbing At this latter temperature a gain in sensitivity occurs so that the roentgen dose may be reduced to 60 to 70 per cent

SUMMARY

A comparison has been made between a series f two roentgenograms of th female breast one intended for 90 second processing th other containing more sil er f r 6 minute processing in a roll machine The latter produced considerably better detail The method as to how industrial film with a high silver content may be incorporated into th processing routin of the a erage clinic is discussed

ZUSAMMENFASSUNG

Es wurd ein Vergleich zwischen Serien von zw ei Rontgenbildern der weiblichen Brust orgenommen das eine abgepasst f r eine 90 Sekunden Entw ckl ng das andere das mehr S lber enthielt fur eine 6-Minuten Entwicklung in einer Drehmaschine Letzteres gab w sentlich bessere Einzelheiten w eder D Verfasser diskutieren die Methode wi industrielle Filme mit einem hohen Silbergehalt in di Entwicklungsroutine einer gewoh lichen Klinik ufgenommen werden konnen

RÉSUMÉ

Les auteurs ont compare une serie de couples de radiographies d seins d femme une de ces radiographies etant faite pour un developpement en 90 secondes et l autre sur un film contenant davantage d argent etait fait pour un developpement en 6 minutes dans une machine à rouleaux Ces dernieres radiographies ont fourni des details bien meilleurs Les auteurs examinent comment on pourrait introduire dans l developpement de routine en radiologi courant des films industriels q contiennent da antage d rgent

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HIGH DOSE UROGRAPHY IN ADVANCED RENAL FAILURE

II. Influence on renal and hepatic function

N. MILMAN and P. STAGE

A prerequisite for routine employment of high dose urography in renal failure is reasonable atoxicity of the contrast medium, especially as regards the organs of excretion, i.e. the kidneys and liver.

Reports dealing with the nephro- and hepatotoxicity of urographic contrast media in advanced renal failure and end stage renal disease are not extensive. The present work was consequently aimed at renal and hepatic function in the periods before and following high dose urography in this type of patient.

Material and Methods. Renal and hepatic parameters were recorded in connection with the high dose urographies described in the previous paper, the material being divided into four groups according to the duration of renal disease (STAGE et coll. 1973). From this material three patients had to be excluded: two because of a pre-urographic creatinine clearance of 0.0 ml/min and one by reason of insufficient recording of renal function. The material thus comprised 47 patients, all in advanced renal failure, with pre-urographic 24 hours endogenous creatinine clearance (= creatinine clearance) below 12.0 ml/min, made up of 24 males and 23 females, mean age 49 years (range 19 to 79 years). None of the patients suffered from multiple myeloma, diabetes mellitus, hepatic insufficiency or urolithiasis.

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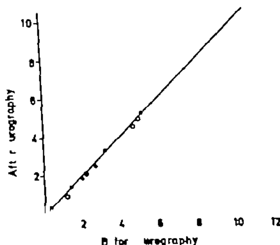


Fig 1 Creatinine clearance before and after one (●) or two (○) urographies in 14 patients on chronic dialysis (group 1)

The technique of urography has been described in the previous paper Part I (STAGE et coll 1973) A dose of 150 ml Urografin 76 % (sodium and methylglucamine diatrizoate) equivalent to 1 5 to 3 7 ml/kg (mean 2 5 ml/kg) was administered without preliminary fluid restriction or laxatives

Serum creatinine and creatinine clearance in each patient were recorded as the averages of 2 to 7 measurements within 8 days before urography Following urography these two data were recorded daily during the first 7 and 4 days respectively Impaired renal function indicated further control until the renal function had stabilized The total post urographic observation period ranged from 7 to 47 days — Serum glutamic pyruvic transaminase was recorded in 36 of the 47 patients as an average of 2 to 5 measurements performed within 6 days before urography and daily the first 4 days following urography

Results

Fig 1 gives the clearance before and after urography in 14 patients on chronic dialysis (group 1) No significant change was evident (Wilcoxon s test $p > 0\ 20$)

Fig 2 referring to 25 patients in steady state uremia (group 2) presents post urographic mean changes as percentages of pre urographic values of creatinine clearance and serum creatinine The levels of significance for these changes as judged by Wilcoxon s test are indicated in Tables 1 and 2 A significant decrease in creatinine clearance greatest on the second day followed

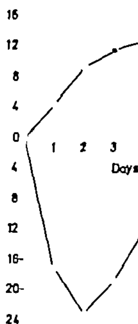



Fig Changes in serum creatinine and creatinine clearance following urography in 25 patients in steady state uraemia (group 2)

by a significant rise was evident The changes in creatinine clearance were accompanied by inverse but delayed significant changes in serum creatinine Neither the creatinine clearance nor serum creatinine returned to pre urographic levels within the first week of observation

The maximum and subsequent minimum decrease in creatinine clearance following urography in all 25 patients is demonstrated in Fig 3 while Fig 4 gives the concomitant changes in serum creatinine in the same group of patients Fourteen of the 25 patients presented both an initial decrease in creatinine clearance exceeding 1 0 ml/min, and an initial increase in serum creatinine exceeding 0 06 mmol/l Figs 5 and 6 indicate that the maximum changes in the renal parameters occurred in these patients within 20 days after urography and pre urographic levels were reached within 45 days following urography in all but 2 patients (Cases 13 and 36)

The initial decrease in renal function appeared to be independent of the underlying disease

Table 1

Significance of change in creatinine clearance following urography in 25 patients with steady state uraemia (group 2)

	Days		
	0—2	2—4	0—4
Creatinine clearance	decrease	increase	decrease
$p < 0.01$			
$0.05 < p < 0.1$			
	(= 20)	(= 20)	(= 21

Day 0 = before urography

Fluid was restricted accidentally before urography in 5 patients. These presented a tendency, although not statistically significant, towards a more marked initial increase in serum creatinine.

Positive correlation between contrast dose and initial increase in serum creatinine (Spearman's test $p < 0.05$) could be demonstrated although correlation between the pre-urographic renal function or the degree of proteinuria and post-urographic decrease in renal function was not observed.

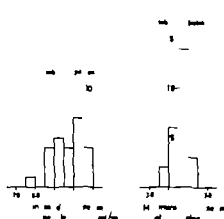
In groups 3 and 4 (8 patients with acute exacerbation in chronic and acute renal failure) a permanent decrease in renal function caused by urography never occurred. However, in one patient suffering from acute tubulo-interstitial nephropathy slowly resolving, urography was followed by a distinct temporary delay in rate of improvement.

Table 2

Significance of change in serum creatinine following urography in 25 patients with steady state uraemia (group 2)

	Days				
	0—1	1—2	1—4	4—7	0—7
Serum creatinine	increase	increase	increase	decrease	increase
$p < 0.01$					
	(= 2)	(25)	(= 2?)	(= 22)	(= 23)

Day 0 = before urography



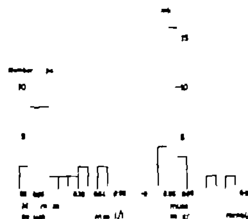
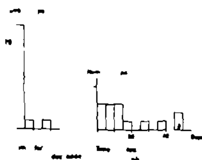


Fig 3

Fig 4

Fig 3 Patients distributed according to maximum and subsequent minimum decrease in creatinine clearance in the total post urographic observation period (group 2)

Fig 4 Patients distributed according to maximum and subsequent minimum increase in serum creatinine in the total post urographic observation period (group 2)



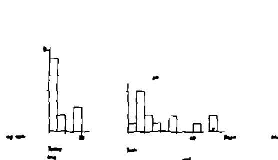


Fig 5

Fig 6

Fig 5 The 14 patients presenting post urographic decrease in creatinine clearance exceeding 1 0 ml/min and an increase in serum creatinine exceeding 0 06 mmol/l distributed according to time for maximum decrease in creatinine clearance and time for reaching pre urographic level (group 2)

Fig 6 The 14 patients presented in Fig 5 distributed according to time for maximum increase in serum creatinine and time for reaching pre urographic level (group 2)

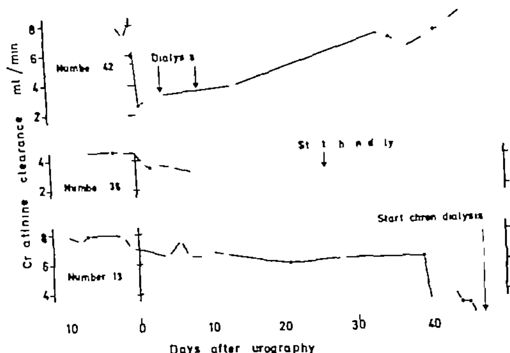


Fig 7 Case reports Changes in creatinine clearance in relation to urography in 3 patients

Case reports

In the total series 3 patients in group 2 presented atypical changes Two had permanent slight impairment of renal function and one had a severe and prolonged but reversible renal impairment following urography

Case 13 Woman aged 49 years (Fig 7) suffering from chronic primary pyelonephritis and in whom during the last 15 years the renal function had been gradually decreasing Urography (contrast dose 2 4 ml/kg) was preceded by fluid restriction Following the examination th creatinine clearance dropped from an a erage of 7 6 t 6.3 ml/min and the serum creatinine rose from 0 71 to 0 98 mmol/l and later stabili ed at 0 91 mmol/l Th diuresis was unchanged The most likely explan ition for the decrease in renal function seemed to be spontaneous progression f the disease lthough the administration of contrast medium possibly in connection with dehydration may also ha e been of some significanc

Case 36 Woman aged 52 (Fig 7) suffering from chronic primary pyelonephritis in whom during the previous 15 years the renal function had been gradually decreasing Urography (contrast dose 3 7 ml/kg) was followed by permanent drop in creatinine clearance from 4.5 to 3 0 ml/min and n in serum creatinine from 0.52 to 0 62 mmol/l The patient received the highest dose of contrast medium administered the most likely explanation for the renal impairment

Case 42 Man aged 35 years suffering from chronic glomerulonephritis (Fig 7) Following urography (contrast dose 2 2 ml/kg) the creatinine clearance fell from 7 8 to 2 7 ml/min and the serum creatinine rose from 0 99 to 1 58 mmol/l the patient became oliguric and in need of dialysis Renal function gradually improved but the pre urographic level was not reached until 45 days after the urography The causal relation between the examination and the renal impairment seems obvious

No alteration in hepatic function as judged from serum glutamic pyruvic transaminase was observed following urography in 36 patients even 4 patients with elevated pre urographic values presented no change

Discussion

The administration of high doses of diatrizoates, even in patients with moderate renal failure, is generally considered a safe procedure and unaccompanied by further deterioration in renal function This assumption is confirmed by experimental investigations in animals (LINDGREN 1961 STOKES & BERNARD 1961) These authors observed no functional or histologic changes in the kidneys following injection of large doses of diatrizoates directly into the renal artery while the administration of acetrizoates caused severe renal damage BENGTSSON et coll (1968) observed no significant change in the clearances of inulin and para aminohippurate after high dose urography with metrizoate in patients with moderately decreased renal function

BARTLEY et coll (1969) estimated renal function in moderate renal failure by single measurements of serum creatinine and renal concentrating capacity before and after the injection of diatrizoate without observing any consistent alterations DAVIDSON et coll (1970) in patients with various degrees of renal failure were unable to demonstrate any significant change in renal function as judged by serum creatinine and the half time of serum iodine during the first 3 days following urography with about 2 ml diatrizoate 60 % or iothalamate per kg body weight SCHWARTZ et coll (1963) however reported a transient rise in serum creatinine after urography with small doses of diatrizoate in 4 out of 131 patients with various degrees of renal failure

STAGE *et coll* (1971) *performed urography after previous fluid restriction* and purging with 80 to 150 ml diatrizoate 76 % in patients with various degrees of impaired renal function they noted a significant transient increase in serum creatinine but no permanent reduction in renal function The higher the pre urographic serum creatinine level the greater the frequency and magnitude of the post urographic rise appeared to be As clearance examinations were not performed it was impossible to exclude the transient rise in serum creatinine being caused by dehydration, either before the examination or as a sequence of osmotic diuresis following the contrast medium

The present results are in accordance with those of SCHWARTZ et coll. The transient decrease in renal function (Fig. 2) seems to be due to a nephrotoxic effect of the contrast medium. Dehydration as an alternative explanation is unlikely as unrestricted fluid intake was allowed both before and after the examination and neither of the patients had any signs of dehydration judged by the clinical condition and weight curve.

The transient decrease in renal function may be so marked that dialysis has to be performed (Fig. 7, Case 42), but a permanent although moderate decrease caused by the examination was also observed (Fig. 7, Case 36).

The risk of further renal injury increases with the amount of contrast medium administered, as indicated by the correlation between the dose and the post-urographic increase in the serum creatinine recorded. It would appear that the dose administered should not exceed 2 to 3 ml diatrizoate 76 % per kg body weight.

There appeared to be no definite difference in the impairment of renal function between patients who were fluid restricted and those not so controlled. However, dehydration per se is a hazard to many uremic patients and should therefore be avoided, even in preparation for urography. Urography in multiple myeloma and diabetes in connection with dehydration seems to imply a special risk of renal injury (MYERS & WITTEN 1971, PILLAY et coll. 1970). The present material without these conditions suggested that the transient decrease in renal function was independent of the nature of the renal disease.

That the liver is the main alternative excretory pathway for contrast media has led to hepatic function examinations following urography (SHERWOOD et coll. 1968, DAVIDSON et coll. 1970). The present results confirm their findings of no changes.

In conclusion, the administration of large doses of contrast medium in advanced renal insufficiency, even without previous dehydration, implies a risk of further renal impairment, generally slight and transient, although sometimes marked and permanent. However, compared with the diagnostic value, the risk of further renal impairment hardly constitutes a contraindication to high dose urography, even in end stage renal disease.

SUMMARY

Renal and hepatic function w[illegible] evaluated in the periods before and after high-do[illegible] urography with an [illegible]erage [illegible] 2.5 ml/kg Urografin 76 % in 47 patients in end stage uremia by frequent recording of serum [illegible]eatinine, endogenous creatinine clearance and serum glutamic pyruvic transaminase. A [illegible]gnificant transient decrease in renal function in one patient indicating temporary dialysis was noted. N[illegible] change in hepatic function was observed.

ZUSAMMENFASSUNG

Die Nieren und Leberfunktionen wurden wahrend der Zeitraum or und nach boch dos erter Urographi mit einer mittleren Dosis on 2 5 ml/kg 76 % igem Urographin bei 47 Patienten mit einer terminalen Uramie durch haufige Bestimmung des Serum kreatinin des endogenen Kreatininclearance und der Serumglutamin Pyruvat Transaminase festgestellt Es wurde ein signifikantes orubergehendes Absinken der N erenfunktion di bei inem Pat enten eine orubergehende Dialyse notwendig machte festgestellt Es waren keine Veranderungen der Leberfunktion zu beobachten

RÉSUMÉ

Chez 47 malades en uremie a stad terminal les auteurs ont determine les fonctions renales et hepatiques par des mesu es frequentes d la creatinine serique de la clearance de la creatinine endogen et d la transaminase pyruvique glutamique serique avant et pres une urographie faite avec ne fort dose d en moyenne 2 5 ml/kg d urografin 76 % ils ont constat une diminution transitoire importante de la fonction renale chez un malad faisant porter l indication d une dialyse temporaire Ils ont pas constate de modif cations de l fonction hepatiqu

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BRAIN VOLUME IN ACROMEGALY

An encephalographic investigation

CLAES RADBERG

Endocrine disturbances are not only associated with changes in the actual hormone producing organ but also, as a rule with functional and morphologic abnormalities elsewhere in the body Judging from the literature possible cerebral changes in various endocrine disorders has received but little attention MOMOSE et coll (1971) demonstrated encephalographically that cortical atrophy of the cerebrum and cerebellum was common among 31 patients with Cushing's disease To elucidate the atrophy more closely they also compared encephalograms of 64 patients with acromegaly and with those of 36 with chromophobe adenoma They found cortical atrophy to be more common in chromophobe adenoma than in acromegaly but by no means so common as in Cushing's disease

No comparison was made with a series of so-called normal encephalograms Neither did they describe the appearance of the ventricular system in patients with acromegaly or chromophobe adenoma only in patients with Cushing's disease They found no correlation between the severity of cortical and central atrophy *HATAM & GREITZ* (1972) found ectasia of the larger cerebral arteries in 13 patients with acromegaly and suggested that the ectasia belonged to the picture of acromegalic splanchnomegaly

From the Department of Diagnostic Radiology Regionsjukhuset University of Linkoping 581 85 Linkoping Sweden. Submitted for publication 28 February 1973

It would appear that no other investigations, at least not radiologic, have been published on the relation between cerebral changes and endocrine disorders

The present investigation of the ventricular system and the size of the grooves as demonstrated in encephalograms of patients with acromegaly was initiated by the observation of unusually small ventricular systems in patients with this disease The findings were compared with those in patients with chromophobe adenoma and in a control material, i e encephalograms of patients without demonstrated intracranial lesion A preliminary report was presented by the author in 1972

Material and methods

Excluded from the material were all cases with a large extrasellar part of the adenoma that unequivocally compressed or displaced the lateral ventricles or that was thought to obstruct the flow of the CSF and cases with hydrocephalus of other origin or where intracranial operations had been performed before the encephalographic examination Three groups of encephalographies were cho en

Group with acromegaly (A) This group consisted of all patients with clinically verified acromegaly and examined encephalographically at Sahlgrenska Sjukhu set, Gothenburg, in 1957—1972 (all together 19 patients) and 11 patients examined at Regionsjukhuset Linkoping, in 1966—1972 The group consisted of 30 patients aged 26—70 years, 16 men (mean age 45 1) and 14 women (mean age 51 0) In 12 patients the adenoma had a suprasellar part that reached 5 to 30 mm above the entrance of the sella turcica

Group with chromophobe adenoma (C) This group comprised encephalo grams of 12 randomly selected patients examined at Sahlgrenska Sjukhuset in 1954—1966 and 22 examined in 1964—1972 at Regionsjukhuset The group was made up of 34 patients aged 21—70 years 19 men (mean age 48 4) and 15 women (mean age 42 9) In 30 cases a suprasellar part of the adenoma extended 2 —28 mm above the entrance of the sella

Control group (N) This material was selected consecutively from the archives of the department of diagnostic radiology Regionsjukhuset obtained during the period 1960—1968 Only encephalograms of not demented patients (BURHENNE & DAVIES 1963) in whom neurologic examination had revealed nothing ab normal and in whom the indication for the examination had been headache, dizziness or epilepsy were accepted Encephalograms with any notable asymmetry or cases with subdural gas or where the width of the anterior horn exceeded one

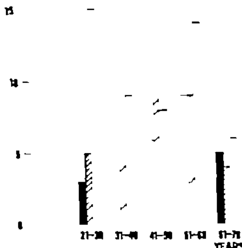


Fig 1 Age distribution and number of patients in the group with acromegaly (■ 50 patients) the group with chromophobe adenomas (▨ 34 patients) and the control group (□ 52 patients)

third of the greatest width of the skull on that side, as measured to the tabula interna, i e Lindgren s ratio (LINDGREN 1951) were not included

There were 52 patients, aged 22—66 years, 34 men (mean age 44 9) and 18 women (mean age 40 9) The cases were intentionally chosen from patients who had been examined a long time previously in order to allow for a follow up of possible cerebral disease at the time of the examination

The age distribution of the patients in the various groups is given in the histogram (Fig 1)

Encephalographic technique All encephalographies had been performed with the fractionated technique described by LINDGREN (1949) and with oxygen as contrast medium The amount of gas in the lateral ventricles was roughly equal and when the patient was supine extended about 1 cm dorsally to the inter ventricular foramina (LARSBY & LINDGREN 1940) Special attention had been given to the filling of the suprasellar cisterns and the subarachnoid space of the convexity If an expanding suprasellar process had been suggested the investigation, as a rule, included tomography

Twenty seven of the examinations (A1 C7 N19) had been performed with Lysholm s skull table with a focus film distance of 70 cm 49 (A15 C17 N17) with Mimer I (FREDZELL & LINDGREN 1959) with a distance of 80 cm between the focus and the object plate which means a focus-film distance of barely 84 cm and the remaining 40 (A14 C10 N16) with Mimer III (FREDZELL et coll

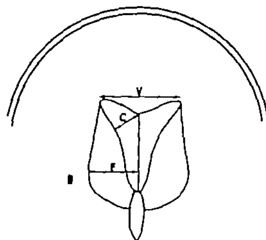


Fig Sketch f encephalogram with patient supine V = maximum width f both ventricular bodies (body span) C = septum caudate distance F = maximum width of anterior horn B = half maximum internal skull width

1968) with a focus object distance of 80 cm to a plane through the auditory canal In a p projection with the patient supine this means a focus film distance of about 94 cm

Measuring technique To appraise the size of the ventricular system and of the grooves various distances were measured (KNUDSEN 1958) with a rule graduated in millimetres The dimensions measured were used uncorrected for roentgenographic enlargement A ratio was most often used instead of absolute values in the evaluation of the dimensions in order to minimise or eliminate differences in roentgenographic enlargement due to variations of focus object film distances, length of the patient s skull and thickness of the head rest etc Distances in the frontal plane were thus divided by the value found for the width of the skull, measured to tabula interna In this way it was also possible to take into account the correlation between the size and shape of the ventricular system and of the skull Numerical estimation of this correlation is necessary in comparing volumes of the ventricular system (EVANS 1942 LINDGREN 1951 SCHIERSMANN 1952 LAUBER 1965 BERG & LONNUM 1966 LODIN 1968) In the supine a p view with the lower part of the orbit projected at the level of the upper border of the pyramid the following measurements were obtained (Fig 2) (1) the greatest width of anterior horn (F) (2) the septum caudate distance (C) (TROLAND et coll 1946 ENGESET & SKAAASTAD 1964 LAUBER 1965) (3) the greatest width of the cella media or ventricular body span (V) (BRUIJN 1959 BURHENNE & DAVIES 1963) and (4) the half greatest width of the skull, as measured to tabula interna (B)

Table 1

Result of the factor analysis of the different measurements in the three groups A, N and C

Ratios and dimensions with demonstrable differences	Level of statistical significance (A acromegaly, C chromophobe, N normal, Y < 40 yrs, O > 41 yrs)			
L. ant. horn, absolute values (F)	A < N < C	($p < 0.05$)		
	Y < O	($p < 0.0$[illegible])		
Ratio L. ant. horn (F/B)	A < N < C	($p < 0.05$)		
	Y < O	($p < 0.05$)		
	♂ > ♀	($p < 0.05$)		
Ratio smaller ant. horn (F min/B)	A < N	($p < 0.05$)	N < C	($p < 0.05$)
Ventricular body span (V)	A < N	($p < 0.05$)	N < C	($p < 0.05$)
	Y < O	($p < 0.05$)		
Ratio ventricular body span (V/B)	A < N	($p < 0.05$)	A < C	($p < 0.03$)
	Y < O	($p < 0.05$)		
Height smaller ant. horn	A < N < C	($p < 0.05$)		
Smaller septum caudate distance (C min)	A < N	($p < 0.05$)	A < C	($p < 0.05$)
	Y < O	($p < 0.05$)		
Width of third ventricle	A < N	($p < 0.05$)	N < C	($p < 0.05$)
	Y < O	($p < 0.01$)		
Width of the grooves in the cerebrum	A < N < C	($p < 0.01$)		
Thickness of ep. pharynx	A > N	($p < 0.01$)		
	A > C	($p < 0.01$)		
Ratio between L and R ant. horn	Left > Right	($p < 0.01$)		

In a lateral projection with the patient supine and the central ray at the level of the anterior part of the anterior horn measurements were obtained of the height of the smallest lateral ventricle about 1 cm anterior of the interventricular foramen where there is normally a small inward bulge in the floor of the anterior horn caused by the most anterior and lower part of the caudate nucleus. The height was measured perpendicular to the roof of the anterior horn (Fig. 7).

The height of the suprasellar part, if any, of the adenoma was measured from the entrance of the sella to the upper pole of the process.

The width of the grooves in the cerebrum was measured not only on films exposed in supine position but also on other films where they were gas filled. Two values were noted, viz. the width of the majority of the wide and the narrow grooves. Two values were noted also when all the grooves were of uniform width. The grooves in the cerebellum were not measured because no special technique had been used to fill them with gas in the present material (THIEBAUT et coll. 1963).

The temporal horns and the height of the fourth ventricle were measured on suitable views and tomograms.

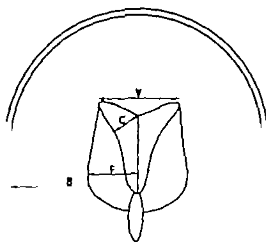


Fig 2 Sketch of encephalogram with patient supine V = maximum width of both ventricular bodies (body span) C = septum caudat distance F = maximum width of anterior horn B = half maximum internal skull width

1968) with a focus object distance of 80 cm to a plane through the auditory canal In a p projection with the patient supine this means a focus film distance of about 94 cm

Measuring technique To appraise the size of the ventricular system and of the grooves various distances were measured (KNUDSEN 1958) with a rule graduated in millimetres The dimensions measured were used uncorrected for roentgenographic enlargement A ratio was most often used instead of absolute values in the evaluation of the dimensions in order to minimise or eliminate differences in roentgenographic enlargement due to variations of focus object film distances, length of the patient s skull, and thickness of the head rest, etc Distances in the frontal plane were thus divided by the value found for the width of the skull, measured to tabula interna In this way it was also possible to take into account the correlation between the size and shape of the ventricular system and of the skull Numerical estimation of this correlation is necessary in comparing volumes of the ventricular system (EVANS 1942 LINDGREN 1951 SCHIERSMANN 1952 LAUBER 1965 BERG & LONNUM 1966 LODIN 1968) In the supine a p view with the lower part of the orbit projected at the level of the upper border of the pyramid the following measurements were obtained (Fig 2) (1) the greatest width of anterior horn (F) (2) the septum caudate distance (C) (TROLAND et coll 1946, ENGESET & SKRAASTAD 1964 LAUBER 1965) (3) the greatest width of the cella media or ventricular body span (V) (BRUIJN 1959 BURHENNE & DAVIES 1963) and (4) the half greatest width of the skull as measured to tabula interna (B)

The ratio for the smallest septum-caudate distance (C min) was not examined with factor analysis but with an earlier performed t test and the following differences were found

$$A < N \ (p < 0.05)$$
$$A < C \ (p < 0.05)$$

No other significant differences were found Evaluation of the results of the investigation requires knowledge of the parameters influencing the ratios and measurements of the CSF spaces and the extent of such influence

Parameters causing variation of ratios in the anterior part of the lateral ventricle In the present investigation these ratios were defined as quotients between distances measured in the ventricle and the greatest half width of the skull The ratios were used for estimating the relation between the size of the ventricular system and that of the skull In order to assess to what extent roentgengeometric and anatomic factors influence ratios, an imaginary model of a skull with a ventricular system in the a p projection (Fig 3) was used

The tangential point that defines the projected width of the skull varies with the value of A which results in a proportionally different enlargement of F and the tangential width of the skull, which in turn naturally causes a change in the ratio The ratio will also vary with the value of R A larger R will result in a smaller ratio as if the volume of the skull had increased It is of course true that with a given value for the greatest width of the skull, a larger radius will embrace a larger volume of the skull, and the ratio is constructed to reflect such a change

It may be questioned whether it is justified to correlate the width of the ventricular system with the greatest outer width of the skull (BERG & LÖNNUM 1966) because it is the volume of the ventricular system and the interior volume of the skull that are correlated and thus volume should reasonably be more closely correlated with the distance to the tabula interna than with the true outer width Furthermore there might be a still closer correlation if width measurements in the ventricular system are compared to skull measurements to the tabula interna in the same frontal plane than if these measurements were done more dorsally To measure the greatest width of the skull at the level of the anterior horns is technically difficult The roentgenographically measured inner width of the skull (projected width) lies closer to the level of the anterior horns than the greatest outer width at least with the focus object distances conventionally used The radius R was selected to analyse the effect of variation in the shape of the skull on the ratio since different shapes of skulls of one and the same greatest width and volume might perhaps give different values for the ratios (Fig 4) Further the ratio may be affected by the variation in the distance H between the measurement in the ventricle and the greatest width of the skull

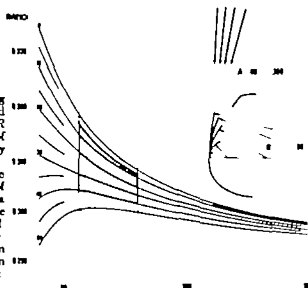


Fig 4 Upper right A arying distances between the focus and the greatest width of the skull R rying radius of the curvature of the skull in th plane defined by the tangential ray Bold arrow the arying divergence of the beam Diagram The ariation of a ratio with A nd R Dotted area denotes the ariations of these factors found in th test material Area limited by broken lines denotes the total possible variation that results when the ariation (1 SD) of H is taken into account

In the diagram (Fig 4) the following fixed values were chosen $F = 2.0$ cm, $B = 7.0$ cm and $H = 5.8$ cm The ratio was calculated for the values 40 41 42 150 cm of A and for each of these values the ratio was calculated for the values 0 5 10 50 cm of R The diagram shows how the ratio varies under these conditions If a limitation is made because of the focus object distances used in the present investigation only values of 56—80 cm will be found for A This analysis showed that the ratio varies inversely with the film object distance and naturally also inversely with the width of the skull in the area of the tangent points on the tabula *interna, which denote the maximum widths of the skull in* the roentgenogram

With knowledge of the influence of R on the ratio an attempt was made to find out whether any difference existed in the curvature defined by R between the group with acromegaly and the control group

In a test material of 11 randomly selected patients with acromegaly and 11 of the controls, axial views of the skull were analysed It was assumed that the outline of the skull in the axial projection coincided approximately with the curvature of the calvaria at the level where the greatest width of the skull was measured in the roentgenogram The radius of the curvature of the skull was measured in the following way For each of the three focus film distances used a beam of diverging lines was traced on a transparent mask The film was placed on this mask so that the bundle of lines corresponded to the rays in the a p projection of the encephalogram (Fig 4 right) The point where the rays formed a tangent to the

Table 2

Value of radius R (cm) indicating curvature of the skull in test material of 11 acromegalic patients and 11 controls

Normal	Acromegalic
13	17
31	24
10	35
6.5	16
20	10
37	12
27	37
19	12
28	11
9	20
13	12
Mean = 19.4	Mean = 17.4
SD = 10.1	SD = 9.5

skull were marked, as was the greatest width of the skull. From these two points the radius of the curvature could be calculated. Since it was found that the curvature of the tabula interna was less well defined, the radius of the tabula externa was used because it was regarded as fully representative of the curvature. The distribution of the radii is given in Table 2. No significant difference was found between the two materials. If allowance be made for the skull radii measured, the variation in the ratio can be limited further to the dotted area in Fig. 4.

To estimate possible systematic difference of the value of H, the sagittal distance between the frontal part of the large wings (which corresponds to the anterior part of the ventricular system) and the greatest width of the skull was measured in the same test material, also in the axial projection. No statistical difference was found between the two materials in this respect either. The mean value of this distance in the group of acromegalics was 5.7 cm with a standard deviation of 0.8. Corresponding value for the control group was 5.9 cm with a standard deviation of 0.5.

If allowance be made for the variation of H with 1 SD and the effect it might have on the ratio, the range of the ratio will be that given by the broken lines beside the dotted area in Fig. 4. It is clear that the variation in the radius (R) has a greater effect than the focus object distance (A).

Summarising, the statistical differences found cannot be explained by differences in R H and A between the three materials Also other ratios refer to the anterior part of the ventricular system, for which reason the investigation made, should apply to the same extent for them

As already mentioned the factor analysis did not reveal any significant difference between the three groups A, C and N regarding the greatest width of the skull measured to the tabula interna

In the few available publications on the measurement of the size of the skull in patients with acromegaly it is claimed that the volume of the skull does not increase except in those patients in whom the disease has started in puberty (MOORE 1952) The youngest patient with acromegaly in the present material had a somewhat large skull The patient was 26 years old at the time of encephalography and had had symptoms and signs of acromegaly for 7—8 years The usually slight increase in the external dimensions of the skull which can be seen in acromegaly in patients in whom the disease appeared after puberty is explained by an increase in the thickness of the vault and of the soft parts The scalp was fully 1 cm in thickness in one of the cases reported by CUSHING & DAVIDOFF (1927)

Variations in measurements of the ventricular system and of the width of the grooves due to technical factors and the encephalographic procedure With different focus-object distances different parts of the ventricular system will form those contours from which the conventional measurements are made This variation is different for different measurements, depending on the anatomic appearance of the ventricular system For instance there is probably no notable variation of the contour forming parts of the surface at the widest width of the anterior horn because these parts are situated on a surface with a very short radius of curvature On the other hand those contours which denote the end points of the septum-caudate distance and the width of the ventricular body are formed by surfaces having a relatively large radius of curvature A change in the film object distance and of angulation may cause a considerable shift in the tangential points In order to analyse this source of error more closely a p encephalograms were obtained with the patient supine and with known variation of the focus object film distance The true absolute measurement of the greatest width of the anterior horn, the septum caudate distance and the width of the body were calculated No notable variation in size was found in these measurements at examination with focus-object distances between 56 and 80 cm, a range which covers the focus object distances used in the present investigation This lack of difference can be explained by the fact that the filling of the ventricular system with gas when the film was exposed, usually extended only down to about 1 cm dorsally to the interventricular foramen and the measurements of the ventricular body (V and C)

were made on or immediately near the contour formed by the interface between gas and fluid at all focus-object distances (TORKILDSEN 1934). That measurements are often made at the gas-fluid level also explains why TROLAND et coll. (1946) as well as ØIGAARD (1971) found no notable variation in the septum-caudate distance on 10° deviation cranially or caudally from the ordinary direction of the beam. Variation in the degree of flexion of the head causes a corresponding shift in the gas-fluid level in relation to the lateral ventricles. Moderate changes in flexion do not cause any notable variation in the measurement because the ventricular system normally is of fairly uniform width in the anterior part of the ventricular body, where the gas-fluid level is usually situated. Neither did the factor analysis of the present material show any significant correlation between the method, i.e. varying focus-object distance, and any ratio or dimension.

Variation in the measurements of the ventricular system may also be explained partly by the fact that the encephalographic procedure causes a change in the width of the ventricular system. Several authors have observed that the lateral ventricles are wider in films taken 24 hours after the initial examination (EVANS 1942, SCHATZKI et coll. 1947, LINDGREN 1951, LE MAY 1967). JIROUT (1956) and ØIGAARD (1971) were able to notice a decrease in size of the lateral ventricles about 20 minutes after the gas injection and thought that the gas is irritative and causes cerebral oedema—and that ventricles expand again after about 24 hours, by when the oedema has abated. LE MAY (1967) has found that oxygen causes small or no changes in volume of the lateral ventricles. Other investigators claim that the ventricular system is only expanded and then already during the injection of the gas, which has been demonstrated in respect of the fourth ventricle by OBERSON et coll. (1969). More detailed examinations of other parts of the ventricular system have been performed by LIM et coll. (1972), who showed that gas filling of the ventricular system for air encephalography caused a widening. The relative increase of the ventricular system was most striking when the initial fractions were injected and less when the later injections were given. The authors conclude that the true size of the ventricular system before the first fraction injected is smaller than what is usually recorded at encephalography.

A necessary prerequisite for obtaining a filling of the ventricular system at encephalography is that it is possible to widen the ventricular system (ROBERTSON 1947). This is accompanied by compression of the subarachnoid space and possibly of compressible [illegible]. Applied to the present investigation one might speculate that the brain in a[illegible]o[illegible]galy is of ordinary volume but less yieldable and that the ventricular system [illegible] egaly is dilated less than ordinarily during the encephalographic proced[illegible]re. An observation arguing against this possibility is

however that if the brain were dilated less than normally on injection of gas into the ventricular system, the subarachnoid space and the grooves should be wider and if anything not be smaller than in controls, where one must expect ordinary compression of the grooves during the encephalographic procedure Conversely that the gas filled ventricular system in patients with chromophobe adenoma is wide cannot be explained by a stronger distension by the gas because if it could, the gas filled grooves would not be wider than ordinarily

Measurements of the ventricular system made in encephalograms thus give an impression of the size of the ventricles distended at the expense of compression of sulci, subarachnoid space and possibly of the veins This distension thus appears to be proportional to the amount of gas injected and the duration of such an injection with possible modifications due to the individual capacity to absorb the CSF and the gas and also of the type of gas used These observations, however underline that if any conclusions are to be drawn, at least concerning relatively small differences in measurements between different encephalograms, the examinations must be made with a uniform technique In the present material the technique was as uniform as reasonably possible Somewhat longer duration of the examination of the patients in the adenoma groups could however not be avoided, as they were, as a rule, examined with tomography Most of the roentgenograms used for determination of the volume in the present investigation were exposed during the later part of the encephalographic examination, that is 30—40 minutes after the first injection of gas, while the ventricular system was still probably somewhat distended

No notable variation in the width of the ventricle has been reported after the first half hour after the end of the injection of gas Not until after 3—24—48 hours have any changes been recorded, and then an increase, most marked in patients with disturbed circulation of the CSF (ROVIT et coll 1972) That at least small differences in examination technique have no decisive effect on the ratio found is suggested by the fact that the present control group showed in men an average value of 0 27 of Evans ratio (EVANS 1942) which is in complete agreement with what has been found by ANDERSEN et coll (1963) in a normal material of 44 adult men The widening caused by the gas injection is probably small to judge from the high correlation between the pneumographic and echoencephalographic determination of ventricular size that SJOGREN et coll (1968) found in infants and children in whom the ventricular system is more easily dilated than in adults PROBST (1972) has reported that the anterior part of the lateral ventricles diminished in width during the temporal horn filling manoeuvre The septum-caudate distance decreased 19—23 per cent but the anterior horn span and the body span only about 1—3 per cent In the present material the measurement as a rule has been taken before the filling of the tem

poral horns as the gas filling afterwards was thought to be insufficient for reliable measurement of relevant distances The great variation of the septum-caudate distance that can appear could not be detected in the investigation by SJOGREN et coll (1968) as this distance cannot reliably be determined with echoenceph alography Their correlation was mainly based on body span and width of the third ventricle

The widths of the grooves cannot be measured exactly because the individual gas filled grooves often vary somewhat in width along their course and they are often superimposed in the roentgenograms, which makes measurement difficult It may also be difficult to decide which grooves should constitute the majority of the wide and the majority of the narrow grooves respectively These difficulties are however probably the same in all three groups so that no systematic dif ference should occur To eliminate the possibility of bias, another radiologist (Bernt Lindholm) who was unaware of the group to which the various roent genograms belonged, measured the widths of the grooves in the same way and arrived at largely the same results In the measurements of the widths of the grooves like the height of the smaller anterior horn the measures from the films were used without correction for the enlargement, because the difference in en largement between the Lysholm and the Mimer stands in the lateral projection was calculated to be only 1 per cent and because the degree of enlargement is small and is fairly constant since the film is exposed as close as possible to the skull

Measurements in the ventricular system and of the width of the skull were also done by a further neuroradiologist (Gunnar Fagerberg) No systematic difference in the re ults between the two observers was found

Conclusions suggested by results of investigation of parameters capable of influencing ratios and other measurements Roentgengeometric and technical factors of the examination thus had no significant effect on the results of measure ments The differences in measurements and ratios demonstrated between the three groups (A N C) were due to true differences in the width of the ventricu lar system and of the grooves

Comments on the results of the factor analysis

The factor analysis (Tab e 1) omewhat unexpectedly showed significant dif ferences in the effect of t hypophysial lesion on the left anterior horn but not on the right, in the evaluation of the absolute measurements The difference decreased somewhat w h n ratios ere evaluated suggesting that the difference was partly due to a var on of enlargement

however that if the brain were dilated less than normally on injection of gas into the ventricular system, the subarachnoid space and the grooves should be wider and, if anything not be smaller than in controls, where one must expect ordinary compression of the grooves during the encephalographic procedure Conversely that the gas filled ventricular system in patients with chromophobe adenoma is wide cannot be explained by a stronger distension by the gas because if it could the gas filled grooves would not be wider than ordinarily

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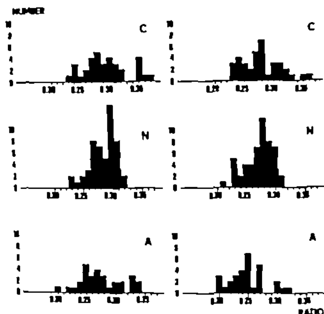


Fig 5 Variation of two ratios in the three groups Left Ratio for the left anterior horn Right Ratio for the smaller horn in each patient

mentioned not more than 1—2 mm Most of the narrower anterior horns are thus situated on the right side Elimination of the wider anterior horns on the right side and incorporation of the corresponding narrower horns on the left side thus results in a significant difference ($p < 0.05$) between the three materials The left anterior horn was smaller in 9 of 30 in the group with acromegaly in 9 of 52 in the control group and in 11 of 34 with chromophobe adenoma The proportion of narrower anterior horns emanating from the left side had, on the average, a ratio of 0 243 The corresponding figure for the narrower anterior horns on the right side was 0 246

In Fig 5 there is a cluster of patients in A and C to the extreme right with the highest ratios These patients might have had injuries not related to the basic disease, causing a widening of the horns N is cut off at ratio 0 33 and thus cannot show any cluster' This reduces the difference to A and increases it to C

The smaller septum caudate distance was evaluated for the same reasons as those given for the anterior horn This measure and its ratio are closely related to the anterior part of the body and in acromegaly it was significantly smaller ($p < 0.05$)

The third ventricle was n[illegible] ver in the patients with acromegaly than in the controls The result of the [illegible]parison with patients with chromophobe adenoma is however possibly less r[illegible] [illegible]ecause all of the 34 patients with chromophobe adenoma except 4 had a su[illegible] adenoma portion which often deformed the



Fig 6 Encephalogram of a 30 year old man with acromegaly with typical small ventricular system and fairly narrow grooves

third ventricle Yet the factor analyses showed no correlation between the occurrence of suprasellar extension and the above difference in width In 9 of the 30 patients with acromegaly the area of the pituitary adenoma had been irradiated The third ventricle at least its anterior lower part is often also irradiated during such treatment It is well known that this has an atrophying effect (WILSON et coll 1972) but the third ventricle was nevertheless narrower in the group with acromegaly than in the other groups

As for the width of the grooves, differences were found between the groups in this material ($p < 0.01$)

That no significant differences could be found regarding the width of the smallest temporal horn or in a earlier t test, of the sum of the width of the temporal horns may probably be explained by the fact that the measure is too small to show a difference, if any with the method used

The height of the fourth ventricle can often be measured with certainty only with the aid of tomography Otherwise it is not possible to distinguish between the positions of the fastigium and the posterior superior recesses (AMUNDSEN & GRIMSRUD 1966 OBERSON et coll 1969 CORRALES & GREITZ 1972) Tomography was used only to limited extent in the controls therefore no certain comparison was possible In addition, the measured height of the fourth ventricle depends on at which time relative to the injection of the gas the film is exposed (OBERSON et coll 1969) Such differences may have masked any true differences between the groups



Fig 7 Encephalogram of 34 year old woman with chromophobe adenoma Ventricular system and particularly the grooves wider than ordinarily The measurement of the height of the smaller anterior horn is indicated with broken line

In summary Patients with acromegaly thus seem to have a relatively smaller ventricular system and on the average, narrower grooves than controls and in these respects they differ still more from patients with chromophobe adenoma Since an increase in parts of the volume of the cerebral parenchyma or of its entire volume is accompanied by a corresponding reduction of the width of the ventricular system and of the subarachnoid space, the smaller dimensions of the cerebrospinal space in patients with acromegaly means that the volume of the cerebral parenchyma in such patients is increased and conversely decreased in patients with chromophobe adenoma (Figs 6 7)

Discussion

Various explanations may be offered for the brain volume in acromegaly One might imagine that the acromegalic brain offers greater resistance to ageing processes than in normals An objection that might be raised against such an assumption, however is that even in relatively young patients with acromegaly the brain is increased in volume, i e before physiologic ageing can be expected

That a suprasellar part of an adenoma should explain the general increase in volume is not likely First because the factor analysis did not show any differences between cases with and without an extrasellar part, and secondly because patients with chromophobe adenoma often had a significantly larger suprasellar part and nevertheless a wider CSF space than the patients with acromegaly

In Cushing's disease which is associated with a high incidence of cortical

atrophy there is a catabolic metabolism of proteins leading to a negative nitrogen balance Acromegaly can be regarded as a counterpole to Cushing's disease, because in acromegaly there is a marked anabolic metabolism which according to MOMOSE et coll (1971) may be related to the low incidence of cortical atrophy in acromegaly No correlation could be found between the duration of the disease and the width of the intracranial CSF space in the group with acromegaly or the group with chromophobe adenoma No analysis of the correlation between the level of the growth hormone and the dimensions of the intracranial CSF space was possible because the number of cases where such hormonanalysis had been performed was too small

That the soft tissues increase in volume in acromegaly such as in the hands and feet (LANG & BESSLER 1961 STEINBACH & RUSSEL 1964 KHO et coll 1970) as well as in the epipharynx, as was apparent from the present investigation ($p < 0.01$) and that the viscera increase in size splanchnomegaly is believed to be due partly to an increased deposition of acid mucopolysaccharides and chondroitin sulphate in the collagen fibrils in the connective tissue, and partly to an increase in size and number of the cells Human growth hormone (HGH) induces the production of somatomedin which is the actual growth promoting factor (HALL 1972) But the brain contains no connective tissue, for which reason it remains to be considered whether the increased volume of the cerebral parenchyma in acromegaly might not be due to an effect of the growth hormone on the brain cells With conventional histologic methods no changes however have been demonstrated in the brain in acromegaly

The increase in brain volume is moderate and probably occurs slowly and is not so marked as to cause papilloedema FINLAY & MACDONALD (1954) found at autopsy *in three acromegalic male patients brain weights of 1 460 g (59 yrs)* 1 230 g (68 yrs) and 1 570 g (40 yrs) Normal brain weight is considered to be 1 250 g CUSHING & DAVIDOFF (1927) in their four autopsied cases reported a brain weight only in one (1 525 g, 52 yrs)

A very common symptom of acromegaly a severe persistent headache, might, however be caused by the increase in volume of the cerebral parenchyma This headache has been assumed to be due to the expansion of the pituitary adenoma in the sphenoidal body and stretching of the dura, but no clear correlation appears to be demonstrable between the enlargement of the sella turcica and the frequency and severity of headache With encephalography demonstrated probable increase of brain parenchyma in an acromegalic patient might contribute to the indication for hypophysectomy or radiation therapy to relieve headache and to prevent pressure atrophy of the brain Hitherto no systematic investigations have been done suggesting that also the brain is involved in the general organomegaly which occurs in acromegaly HATAM & GREITZ (1972)

examined only the large vessel trunks, the carotid in the region of the neck and the proximal intracranial arteries which run from the urface of the brain in the cisterns and which probably not contribute considerably to the increase in volume of the cerebral parenchyma

Investigations of number and size of the brain cells are required to explain the increased brain volume in acromegaly

Addendum in proof

Since the preparation f this communication UTHNE et coll (1974) ha partly purified a human hormone that has been called somatomedin B to distinguish it from the somatomedin A isolated by HALL (1972) WESTERMARK et coll (1974) hav shown th t somatomedin B stimulates the synthesis of DNA in human glia cells in tissue culture Somatomedin A and B are both human growth hormone (HGH) dependent An increased amount f glia may thus hypothetically contribut to the increased lume of the cerebral parenchyma in cromegaly

Acknowledgement

The statistical analysis was carried out by M Lars Lindwall lecturer in statistics Uni versity of Linkoping Linkoping Sweden

SUMMARY

In 30 acromegalic patients the brain lum was investigated from encephalographic measurements A comparison was made with 34 patients with chromophobe denoma and a contr l group of 52 patients With statistical f ctor analysis it was found that patients w th acromegaly had a significantly increased volum f the cerebral parenchyma and in patients with chromophobe adenoma t was somewhat decreased The etiology and impl cations f these observations are discussed

ZUSAMMENFASSUNG

Bei 30 Patienten mit Akromegalie wurde aus encephalographischen Messungen das Gehirn olumen bestimmt Ein Vergleich mit eruddreissig Patienten mit einem chromophoben Adenom und mit einer Kontrollgruppe von 52 Patienten wurde gemacht Mittels statistischer Faktor Analyse wurd festg lt dass Patienten mit Akromegalie ein signifikant hoheres Volumen des cerebralen Parer h ma hatten wahrend das on Patienten mit einem chromo phoben Adenom etwas gering ar Die Atiologie und Bedeutung d eser Beobachtungen werden besprochen

RÉSUMÉ

L auteur determine l h du cerveau à partir de mesures en ephalographiques chez 30 acromegales Il a f it ur cor paraison avec le volume cerebral de 34 malades atteints d adenome chromopho d roupe 52 témoins L analyse statistique a montre que le olume du parer cl cora des ac omegales est significativement ugmente et qu il est un peu diminue n lades atteints d adenome chromophobe L auteur etud l étiologi et les impli n d observations.

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CORTICAL BONE MASS IN ACROMEGALY

D G IKKOS K NTALLES CH VELENTZAS and P KATSICHTIS

The prevailing opinion that acromegaly is often associated with osteoporosis (ALBRIGHT & REIFENSTEIN 1948 BELL & BARTTER 1967 DAUGHADAY 1968, SERRE et coll 1970) needs, according to DOYLE (1967) considerable qualification since it is based on visual qualitative estimation of the mineral content of bone in roentgen films which generally is considered inadequate for the estimation of bone mass (LACHMAN 1955 BLAND et coll 1969) Furthermore, recent skeletal surveys of acromegaly by NADARAJAH et coll (1968) and JULIANI et coll (1970) failed to confirm the older reports in agreement with the results of the two quantitative estimations of bone mass in acromegaly available so far Thus the mineral content of the distal third of the ulna of 53 acromegalics, as investigated by densitometry with roentgen films has been classed as normal by DOYLE (1967) while RIGGS et coll (1972) gave increased values obtained by the method of CAMERON & SORENSON (1963) While DOYLE (1967) had not been able to find clear cut vertebral osteoporosis in his 54 patients, RIGGS et coll (1972) described such changes in 11 of their 28 patients, with small but definite anterior wedge compression in 2 of these 11 patients

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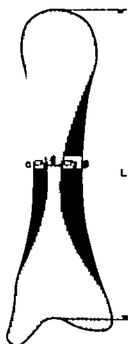


Fig 1 Schematic representation of the measurements of the left second metacarpal L = length a—β = external diameter (D) d = internal diameter CT + CT = cortical thickness (CT)

Osteoporosis in acromegaly is of practical as well as of theoretic interest in the sense that osteopenia seems to be an unexpected phenomenon in a condition leading to increased skeletal growth, a. in acromegalic gigantism A re-evaluation was therefore considered worthwhile by measurements of the cortical bone mass, using as a parameter the results of morphometric observations of the left second metacarpal bone—a technique generally available

Material and Method The materi l co .sisted of 65 acromegalics 27 males aged 17 to 59 and 38 females ag 19 to 67 years Morphometric observations of the left second metacarpal bone re made in conventional roentgenograms obtained at a FFD of 80 cm A mi ne with a vernier (Taschenmessloupe TM4 C Zeiss) pro' iced the follow asurements in each subject (Fig 1) a) total length (L) external iame r (D) (a—b) c) internal diameter (d) and d) cortical t ickness ($CT = CT_1 + CT_2$) D d and CT being measured at the middl f the bone

The Exton Sm ndex was calc ated from the formula

$$\frac{D - d}{L - D}$$

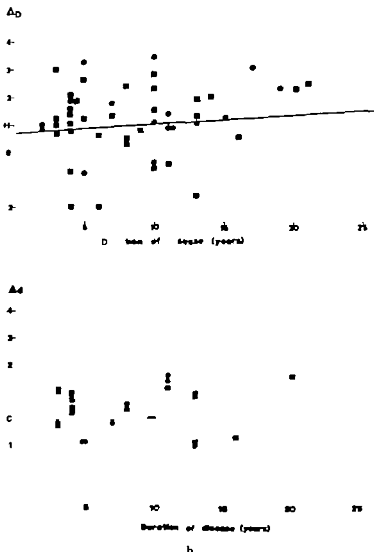


Fig 2 Relationship between duration of disease and normalized difference from normal of) th external (= 0 384 $p < 0.01$ Y = 0 69 + 0 0284x) and b) the internal (= −0 297 $p < 0.02$ Y = 0 36 − 0 0165x) diameter of the left second metacarpal bone (ΔD) in 65 cromegalic patients ● males ■ females

The data of acromegalics of the present investigation were compared to those obtained by the same technique in a group of 381 male and 1 522 female control Greek subjects, aged 16 to 90 years, reported elsewhere (Ikkos et coll 1972)

The level of fasting plasma growth hormone was measured in 40 of the 65 patients by a double antibody radioimmune assay method based on that described

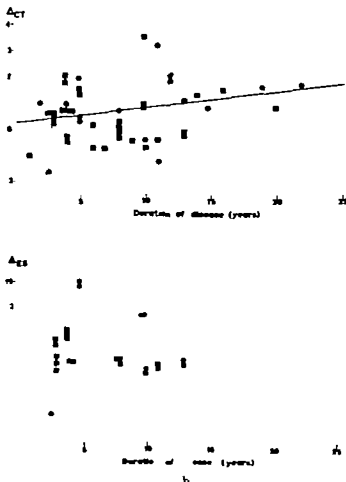


Fig 3 Relationship between duration of disease and normalized difference from normal of a) the cortical thickness of the metacarpal bone (Δ_{CT}) ($r = 0.858$, $p < 0.001$), $Y = 0.764 + 0.0546x$) and b) the EXTON SMITH index of the metacarpal bone (Δ_{ES}) in 65 acromegalic patients ● males females

for insulin by MORGAN & LAZAROW (1963) as modified by JACKSON et coll (1968) and with the standard and iodinated HGH (^{125}I) commercially available as a kit from CEA CEN SORIN.

The statistical analysis of the results was performed by standard techniques (SNEDECOR & COCHRAN 1971)

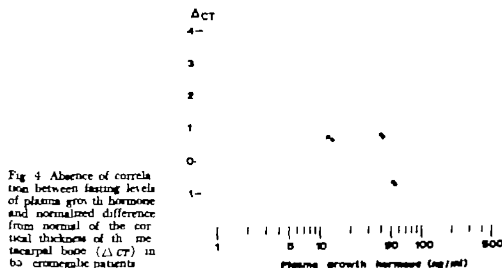


Fig 4 Absence of correlation between fasting levels of plasma growth hormone and normalized difference from normal of the cortical thickness of the metacarpal bone (Δ_{CT}) in 65 acromegalic patients

Results

The change in cortical bone mass with age and the differences between the two sexes (GARN 1970 NEWTON JOHN & MORGAN 1970 VIRTAMA & HELELA 1969 IKKOS et coll 1972) indicated that the values of the acromegalics could be grouped together (Figs 2 to 4) only after being normalized by the formula

$$\Delta = \frac{X - \bar{X}}{SD}$$

where Δ = normalized difference
X = true value
$\bar{X}$ = mean normal value *for corresponding* sex and age and
SD = standard deviation for the normal population

The external diameter (D) of the metacarpal was larger than that of the control group in 49 (or 75 per cent) of the acromegalic patients ($X = 16\ 754$ $p < 0\ 001$) the mean Δ for D being $0\ 94 \pm 0\ 163$ a value significantly larger than zero ($p < 0\ 001$) (Fig 2 a) (All $\pm$ values represent the standard error of the mean unless stated otherwise) A significant positive linear correlation ($r = 0\ 384$ $p < 0\ 01$) between Δ_D and duration of the disease was thus evident

The internal diameter (d) of the acromegaly patients (Fig 2 b) was not different from that of the controls the normalized difference for d (Δ_d) being positive in 39 (or 61 per cent) and negative in 25 (or 39 per cent) of the 65 acromegaly patients ($X = 3\ 06$ $p > 0\ 05$) The mean Δ_d was $0\ 21 \pm 0\ 124$ a value not significantly different from zero ($p > 0\ 05$) As evident from the significant ($p < 0\ 02$) negative linear correlation ($r = -0\ 297$) of the values in figure 2 Δ_d decreased with an advancing duration of acromegaly

As a result of the increase in the external diameter with the internal diameter remaining practically unchanged the cortical thickness was significantly greater in acromegaly (Fig 3 x) of the 65 patients involved 48 (or 74 per cent) had values above those of the control group while these were smaller in 17 (or 26 per cent) ($X = 14785$ $p < 0001$) the mean difference from the normal subjects (Δ_{CT}) being 075 ± 0141 ($p < 0001$)

Because of the advancing increase in external diameter (Fig 2 a) and decrease in the internal diameter (Fig 2 b) with the duration of the disease, cortical thickness also increased progressively as indicated by the strong positive linear correlation ($r = 0858$ $p < 0001$) between Δ_{CT} and duration of the disease (Fig 3 a) That the increase in cortical thickness with duration of the disease was not due to an overall increase in the size of the metacarpal was demonstrated by the index proposed by EXTON SMITH et coll (1969) by which the cortical thickness is normalized for the size of the bone The normalized difference for the EXTON SMITH index (Δ_{ES}) was positive in 42 (or 65 per cent) and negative in 23 (or 35 per cent) acromegaly patients ($X = 13087$ $p < 001$) with a mean Δ_{ES} value of 062 ± 0171 i e one significantly different from zero ($p < 0001$) (Fig 3 b)

Sex had no influence on the changes of cortical bone mass in acromegaly (Figs 2, 3) The activity of the disease at the time of the examination as estimated from the fasting plasma growth hormone level, was also of no significance on the changes in cortical bone mass observed (Fig 4)

Discussion

Morphometric observations on roentgenograms of the metacarpal bones for the assessment of cortical bone mass introduced by VIRTAMA & MAHONEN (1960) and BARNETT & NORDIN (1960) is now well established (VIRTAMA & HELELA 1969 GARN et coll 1971) The results obtained by this simple and generally available technique compare well with those by other more complicated procedures (MAZESS et coll 1970) and a high degree of correlation exists between the findings from the metacarpals and those from other long bones of the body (HELELA & VIRTAMA 1969) Although measurements of the cortex of the latter may also be used (MEEMA 1969 CAMERON 1970) the left second metacarpal bone was selected for the present work since this was the only bone for which values for a large group of healthy Greek subjects were available (IKKOS et coll 1972)

The necessary limitation of the observations to a single bone may raise doubts as to whether the changes in the metacarpals in acromegaly may be used as a parameter of similar changes of the whole cortex Examination of the films of

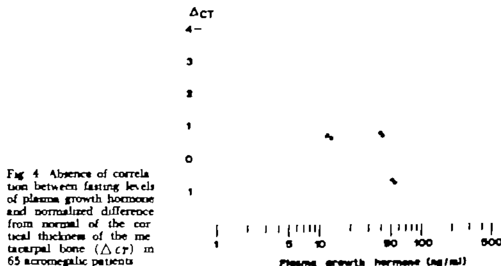


Fig. 4. Absence of correlation between fasting levels of plasma growth hormone and normalized difference from normal of the cortical thickness of the metacarpal bone (Δ_{CT}) in 65 acromegalic patients.

Results

The change in cortical bone mass with age and the differences between the two sexes (GARN 1970, NEWTON-JOHN & MORGAN 1970, VIRTAMA & HELELA 1969, IKKOS et coll. 1972) indicated that the values of the acromegalics could be grouped together (Figs. 2 to 4) only after being normalized by the formula

$$\Delta = \frac{X - \bar{X}}{SD}$$

where Δ = normalized difference
X = true value
$\bar{X}$ = mean normal value for corresponding sex and age and
SD = standard deviation for the normal population.

The external diameter (D) of the metacarpal was larger than that of the control group in 49 (or 75 per cent) of the acromegalic patients ($\chi^2 = 16.754$, $p < 0.001$), the mean Δ for D being 0.94 ± 0.163, a value significantly larger than zero ($p < 0.001$) (Fig. 2 a). (All $\pm$ values represent the standard error of the mean, unless stated otherwise.) A significant, positive linear correlation ($r = 0.384$, $p < 0.01$) between Δ_D and duration of the disease was thus evident.

The internal diameter (d) of the acromegaly patients (Fig. 2 b) was not *different from that of the controls, the normalized difference for d* (Δ_d) being positive in 39 (or 61 per cent) and negative in 25 (or 39 per cent) of the 65 acromegaly patients ($\chi^2 = 3.06$, $p > 0.05$). The mean Δ_d was 0.21 ± 0.124, a value not significantly different from zero ($p > 0.05$). As evident from the significant ($p < 0.02$) negative linear correlation ($r = -0.297$) of the values in figure 2, Δ_d decreased with an advancing duration of acromegaly.

modelling—and subperiosteal bone formation—are more active in acromegaly than in normal subjects

It should be mentioned that in normal subjects the internal diameter also increases progressively with age and that after middle age this increase largely exceeds that of the external diameter leading to the thinning of cortical bone so characteristic of senile osteoporosis (VIRTAMA & HELELA 1969 GARN 1970 NEWTON JOHN & MORGAN 1970 CAMERON 1970 IKKOS et coll 1972) The fact that the difference between the true values and those expected for sex and age for the internal diameter of the acromegaly patients (Δ_d) became smaller with the duration of the disease (Fig 2 b) suggests progressive slowing down in the normally occurring bone reabsorption It should be pointed out, however that the slowing down in the bone reabsorption as acromegaly progresses does not necessarily mean a decrease in the absolute rate this may represent a decrease in the bone reabsorption relative to the increased new subperiosteal bone deposition, processes that are normally coupled together

The present suggestions as to the mechanism of the increase in the cortical bone mass in acromegaly are in good agreement with other observations Thus periosteal new bone deposition in the short and long tubular bones although not striking, is a well known phenomenon in acromegaly It is similar to the marginal subperiosteal formation of new bone of the vertebrae which together with the increase in the size of disks—secondary to marginal subperichondrial new formation of cartilage—leads to a squatty shape of the bodies this change has usually been interpreted as being due to a decrease in the height of the bodies whereas actually the change in proportion is the result of widening of the bodies (JAFFE 1972)

Tetracycline labelling examinations of the bones of 2 acromegaly patients have revealed an increase in the overall bone formation rate of the active case (RAMBER et coll 1966) and a normal value in the other inactive case (VILLANUEVA et coll 1966) ROELFSEMA et coll (1971) demonstrated with microradiography an increase in the average volume of trabecular bone as well as an activation of both formation and resorption of bone in the cortical and subcortical regions with a slight increase in the trabecular bone formation RIGGS et coll (1972) by the same technique reported that forming surfaces exceeded resorbing surfaces in cortical bone in acromegaly and that both were increased above normal an increase positively correlated to the serum growth hormone level Thus accelerated bone remodelling led to increased bone width and an increased or normal cortex Finally HARRIS & HEANEY (1969) have observed a marked increase in the rate of formation of cortical bone and a net increase in the bone mass of six adult dogs given growth hormone for six months

other long bones of acromegaly patients—with changes similar to those in the metacarpals—indicate that the results from measurements of the metacarpals are useful parameters for total cortical changes in this condition

The possibility that the increase in cortical thickness in acromegaly may represent an increase in bone volume without an increase in bone mass can be excluded since measurements by the photon absorption technique of CAMERON & SORENSON (1963) of the metacarpals of 10 acromegalic subjects gave increased values (unpublished observations)

The opinion that the results of the present investigation based on measurements of the second metacarpal bone are valid for the whole cortical bone mass is strongly supported by the aforementioned results of RIGGS et coll (1972) These authors reported increased absorption of roentgen rays of the middle of the radius in 20 acromegalics while ALOIA et coll (1972) writing on total body calcium of acromegalic patients as measured by neutron activation analysis in vivo, stated that the values for the acromegalics varied between 88 8 and 122 5 per cent of those expected for normal subjects on a height basis, with 8 of the 10 values over 109 1 per cent The increase in cortical bone mass now given is in agreement with the experimental results of HARRIS & HEANEY (1969) in six dogs that had an increase in bone mass after 6 months treatment with growth hormone

The present findings that both cortical thickness and cortical surface area normalized for bone size (EXTON SMITH index) proved to be significantly larger in acromegaly than in normal subjects demonstrate that cortical bone mass is significantly increased in acromegaly The fact that the increase in cortical thickness of the acromegalics resulted from an increase in the external diameter while the internal diameter was normal permits indirect evaluation of the mechanisms responsible for the increase in cortical bone mass in acromegaly Since an increase in the external diameter signifies accelerated subperiosteal bone formation and since the normal size of the internal diameter indicates normal bone reabsorption, acromegaly should be classified according to GARN et coll (1971) as a condition characterized by increased bone formation, normal bone loss

It should be mentioned that the external diameter increases directly with height up to the completion of bodily development and thereafter slowly to old age, as a result of skeletal development initially and then constant bone remodelling (SMITH & WALKER 1964 BONNARD 1968 VIRTAMA & HELELÄ 1969 GARN 1970 NEWTON JOHN & MORGAN 1970 IKKOS et coll 1972) The findings that the difference between the true values and those expected for sex and age for the external diameter of acromegaly patients (Δ_D) became more positive with the duration of the disease (Fig 2 a) demonstrate that bone re

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FROM DEPARTMENT OF DIAGNOSTIC RADIOLOGY II (DIRECTOR PROF I WICKBOM)
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MOYA MOYA VESSELS
COLLATERAL ARTERIES OF THE BASAL GANGLIA
Malignant occlusion of the anterior cerebral arteries

KLAS ROSENGREN

The cerebrum is protected from ischaemia by several types of collaterals particularly the circle of Willis the collaterals from the external carotid arteries including the transdural communications (a rete mirabile, MOUNT & TAVERAS 1957) and the leptomeningeal (pial) anastomosis (LANNER & ROSENGREN 1964)

Obliterating arterial disease is much more common in Japan than in the United States or Europe TAKEUCHI (1961) reported two cases of carotid arterial stenosis and abnormal net like blood vessels at the base of the brain The appearances of the blood vessels suggested the term moya moya to indicate the resemblance of the many small vessels to a hazy puff of cigarette smoke [illegible] moya moya in Japanese) SUZUKI & TAKAKU (1969) considered the abn[illegible] vessels at the base of the brain and the various types of carotid sten[illegible] and parcel of a particular disease An investigation of 20 patien[illegible] several stages The condition apparently starts with a narrowing of t[illegible] cranial part of the carotid vessel and the moya moya vessels appe[illegible] ally to disappear again as other collateral pathways become established The moya

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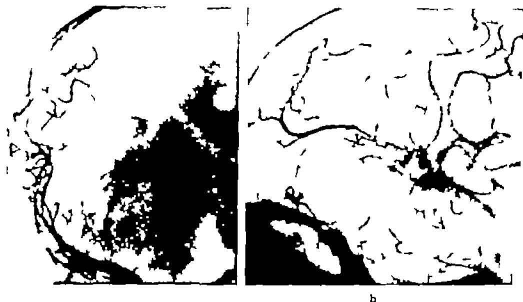


Fig 1 Angiography of the right carotid artery a) A p b) Lateral Large midline basal tumour with lateral displacement of hypertrophied arteries of the basal ganglia Part of th pericallosal rtery is revealed by the collateral function of these arteries Unfilled anterior cerebral artery

moya vessels were evident in patients of all ages up to 50 years, although 12 out of 20 were under the age of 20 These vessels were originally considered to be present only in the Japanese race and only few reports of vascular changes of the moya moya type have been published in Europe GERLACH et coll (1967) have presented a case with a vascular structure similar to the moya moya Clinical information was absent and the legend to the figure read merely capillary angiectasis A similar case was published by KRAYENBUHL & YAŞARGIL (1965) who also termed the appearance capillary teleangiectasis and provided little further information TAVERAS (1969) however reported 10 cases 6 of them collected from various parts of the United States all with multiple progressive intracranial occlusions Six children in this series had extensive networks of vessels at the base of the brain

Case report

Boy aged 4 was admitted with a possible intracranial tumour no hereditary diseases recorded Birth and development were quite normal to the age of one when he started to have concomitant strabism that was impossible to treat ow ng t lmost total blindness in the left eye no attempt was made to examine the cause Th present condition started in connection with a respiratory infection with marked fatigue and night headache He also

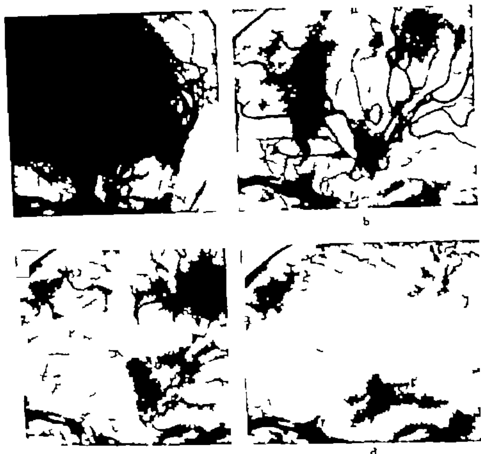


Fig 2 Angiography of the left carotid artery) b) Arterial phase) Lat rterial phase d) Precapillary phase Many almo t parallel arteries extend from the base of the skull around and into the basal mass most are regular but late in the arterial phase be come gradually hazy—the moya moya appearance some re branches from the narrow and stretched right anterior cerebral rtery

had some difficulty with balan and weakness f the left leg Lumbar puncture revealed high pressure of the cerebrospinal fluid Th Babinski sign was positive bilaterally and the patient had spasti reflexes in the left arm and leg

The skull was wider than normal with diastasis f the sutures of 3 to 4 mm the dorsum sellae was almost completely missing No intracranial calcifications were evident Angio graphy of the internal carotid arteri revealed large expansive mass rising from the base of the skull Neither the l ft no the right anterior cerebral artery wa normal in appearance The right anterior cerebral artery was absent and the left was nar ow Several straight and arched arteries probably h pertrophic arteries of th basal gangl n from the basal structures (Figs 1 2) Som of the branches of the right per llosal artery were filled via the abnormal arteries (Fig 1) Ventriculography indicated tl n ws t be



Fig 3 Postmortem examination The tumour almost with symmetric extension on both sides of the midline surrounds the third ventricle A postoperative haematoma lies to the left of the mass

well outlined with rounded contours bulging into both lateral ventricles Craniotomy and extirpation of a large left solid tumour was performed The mass was growing into the left hemisphere partly adherent to the base of the skull and sella turcica It was well demarcated and at least in its upper part covered with ependyma the anterior part was hard and attached to the left lesser wing of the sphenoid and the anterior clinoid process The tumour indented the posterior part of the sphenoid planum During the operation the mass gave the impression of being a meningioma The left anterior cerebral artery was stretched narrow and deeply buried in a groove in the lateral aspect of the mass The left optic nerve was impossible to identify the right was normal in appearance The tumour was inoperable Two days after the craniotomy the patient died of repeated gastrointestinal haemorrhage

Postmortem examination revealed a large well outlined tumour measuring 4 cm×4 cm× 5 cm in the midline with extension on both sides and invading the structures around the third ventricle (Fig 3) Microscopic examination disclosed a typical spongioblastoma polare The left anterior cerebral artery was narrowed and stretched along the surface of the tumour the right anterior cerebral artery was not identified The left optic nerve was absent and the observations from the preceding operation as to the appearance of the base of the skull were verified The many narrow arteries were not evident proximally because of blood clots and neoplasm Several thin walled branches were present more distally at the medial surface of the left hemisphere Microscopic examination disclosed a large number of meandering arterial vessels of various diameters but with generally thickened internal elastica which however in many places was absent (Fig 4) The vessels described were at a distance from any kind of infiltration

Discussion

The many fine parallel arteries appearing at the angiography bore no resemblance to tumour vessels These arteries built up a collateral flow and above the level of the tumour filled the displaced and interrupted right pericallosal artery



Fig 4 Microscopy of the many narrow arteries arranged in a parallel fashion and extending into the cerebral parenchyma from the base of the skull No malignant tissue

(Fig 1) Such transformation into a normal artery never occurs in ordinary tumour vessels The arteries described bear some resemblance to moya moya arteries especially in the late arterial phase (Fig 2 c, d)

The occlusions of the right and left anterior cerebral arteries were not caused by primary arterial disease but rather by compression from outside over a long period of time This compression had in all probability commenced as early as three years before admission The patient was one year old when he developed blindness of the left eye The tumour grew slowly during the first years and had among other things caused deformation of the base of the skull (the erosion of the sphenoidal planum and dorsum sellae) The tumour was at least partly covered by a capsule and no evidence of overgrowth either to the bone or to the vessels was found The vessels resembling moya moya appeared to have developed to compensate for the compression of the anterior cerebral artery so that in spite of a gradually increasing compression the circulation was preserved The abnormal vessels were obviously collateral vessels and probably of the same type as TAVERAS (1969) described in his 1968 Caldwell lecture This author collected 10 cases of intracranial arterial occlusions and at least in 6 cases found 'large network of fine vessels in the region of the basal ganglia and upper brain stem He stated that it is also evident that when the disease process starts early in childhood or during infancy the development of the network in the base of the brain is apt to be greater HANDA & HANDA (1972) also reported that the moya moya like vessels at the base of the brain in all probability might be considered as collateral pathways created by an extraordinary development of perforating vessels to the basal ganglias These authors were able to demonstrate in

5 of 27 cases that the collateral pathways played a role in the circulation to the peripheral arteries They also described a case in which the internal cerebral artery was reconstructed by the vascular network in the same way as occurred in the present case with filling of the displaced branches of the right anterior cerebral artery This fully supports the opinion that, especially among children, long progressive occlusion of the upper part of the internal carotid artery or the proximal parts of the anterior and medial cerebral arteries creates the condition suitable for dilating fine arteries of the basal ganglia These arteries have the *ability of maintaining the circulation to the hemisphere in spite of the proximal* occlusion of the original artery The present case raises no suggestion of primary vascular disease as the whole development was in all probability caused by the slowly growing basal tumour

SUMMARY

Enlarged arteries of the basal ganglia (moya mova arteries) acting as collaterals have usually been regarded as part of specific Japanese disease Similar cases with arterial oc clusion also from other countries have however been described in recent years in the litera ture A case is presented in which such arterial changes were pparently caused by gradual occlusion of the anterior cerebral arteries by a slowly growing tumour

ZUSAMMENFASSUNG

Eine Erweiterung der Arterien der Basalganglien (moya moy Arterien) die eine Kol lateralfunktion haben wurde bisher als typisch fur eine spezifisch japanische Erkrankung betrachtet Ahnliche Falle alle mit arteriellem Verchluss sind jedoch in den letzten Jahren auch or anderen Landern in der Literatur beschrieben worden Ein Fall wird beschrieben i dem die Arterien ls Kollateralgefasse wirkten was anscheinend durch einen ll mahlichen Verschluss der A cerebralis anterior durch einen langsam wachsenden Tumor *verursacht war*

RÉSUMÉ

L augmentation de calibre des arteres des noyaux gris centraux (artères moya mov) fonctionnant comme des collatérales habitu llement et consideree comm une partie d une maladie japonaise specifique Cependant des cas semblables comportant une occlusion artérielle ont aussi ete decrits dans la litterature ces dernières annees L auteur presente un cas dans lequel des lesions arterielles analogues etaient apparamment causees par une ob struction grad elle des arteres cerebrales anterieures par une tumeur developpement lent

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FROM THE DEPARTMENT OF RADIOLOGY SANTA MONICA HOSPITAL MEDICAL CENTER, SANTA MONICA, CALIFORNIA 90404 U S A

ANGIOGRAPHIC ABNORMALITIES IN COMBINED MYOSITIS OSSIFICANS AND DIGITAL ISCHEMIA OF THE HAND

Report of a case

ADAH M DUNCAN

Occasionally findings of a bony tumor mass may be associated with arterial and venous occlusions To differentiate between a vascular dysplasia, malignant tumor or myositis ossificans angiography is a valuable tool (ACKERMAN 1958, HERZBERG & SCHREIBER 1971 LAGERGREN et coll 1960 LEVIN et coll 1972 MARSHALL et coll 1966 STENER & WICKBOM 1966) This paper presents a case of myositis ossificans in association with posttraumatic digital ischemia

Case report

A 36 year old white male cement finisher complained of increasing numbness and stiffness of the fourth and fifth digits of his left hand Episodes of pain in the left palm brought him to medical attention two years after the onset of symptoms At that time a detailed history revealed that he rested his left palm on the handl of a trowel while squatting and smoothing

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Fig 1 Left hand A bony mass involving the fourth and fifth metacarpals

cement with trowel in his right hand As he moved from one position to the next the left palm acted as pivot point bearing considerable weight He worked this w y for 10 years and was forced to give up his job after suffering increasing pain and stiffness of th left hand At that time he first noted hard mass deep on the palmar surface of his hand Swelling and paresthesias gradually developed

Initial films in March 1972 were considered negative In April early nev bone formation adjacent to the fourth and fifth metacarpals was identified Later in the sam month new bone formation appeared extending the length of th shafts of the fourth and fifth metacarpals and filling the space between (Fig 1)

Angiography Twenty ml Renografin 76 % was injected manually in the left brachial artery with serial films exposed over the hand using a magnification technique These films demonstrated narrowing of the ulnar artery with attenuation in the hypothenar space The arterial phase showed the area of mass to be hypervascular however no arteriovenous hun or enous lakes ere seen There were small occlusions f the lar metacarpal rteries in the region f the mass The superficial and deep palmar arches were incomplet (F a) In the enous phase there was considerable accumulation of contrast medium and enous occlusions f the proximal portions f the digital ens of the third fourth and fifth fingers (Fig 2 b) Exploration of the palmar space ith biopsy and fasciotomy was carried out The pathologic diagnosis was metaplastic bone consistent with myositis ossificans circumscript





b

Fig 2) Angiography arterial phase Incomplet superficial and deep palmar rch nd narrowing in the ulnar artery distribution b) Venous phase subtraction Occlusion of the digital eins of the third fourth and fifth digits Accumulation of contrast medium in the region of the myositis ossificans

Discussion

The hypothenar hand syndrome (CALENOFF 1972 CONN et coll 1970) occurs secondary to repeated blunt trauma (KLEINERT & VOLIANITIS 1965 ZWEIG et coll 1969) to the ulnar artery as it passes adjacent to the hook of the hamate In such cases the superficial and deep palmar arches are usually incomplete The ulnar artery which divides into two branches distal to the pisiform bone terminates at the superficial palmar arch The principle blood supply to the fourth and fifth digit is from the digital arteries of superficial arch origin In the present case there was occlusion of the superficial and deep palmar arches This was accompanied by narrowing of the digital arteries to the fourth and fifth fingers In addition to these findings there was a tumor like accumulation of contrast medium seen in the late arterial and early venous films in the area of the localized

myositis ossificans This finding has been reported by previous authors (HUTCHISON et coll 1972) in the active stage of this disease In the venous phase occlusion of the digital veins was identified This finding has not been previously reported, and appears to represent a mechanical venous obstruction secondary to compression of the digital veins as they pass over the area of localized myositis ossificans and under the palmar aponeurosis Clinically this resulted in marked swelling of the fourth and fifth fingers

SUMMARY

Two manifestations of occupational trauma in 36 year old cement finisher are presented These include localized myositis ossificans and posttraumatic digital ischemia Localized hypervascularity and areas f enous obstruction were observed related t the myositis ossificans as well as to arterial narrowing

ZUSAMMENFASSUNG

Es werden zwei Zeichen eines Berufstraumas bei einem 36 Jahre alten Zementhersteller beschrieben Diese umfassen eine lokalisierte Myositis ossificans und eine posttraumatische digitale Ischämi Es wurde eine lokalisiert Hypervaskularitat und Gebiete venoser Obstruktion als Folge der Myositis ossificans sowie der arteriellen Einengung beobachtet

RÉSUMÉ

Presentation de deux manifestations d traumatism professionnel chez un cimentier retoucheur age de 36 ans Elles comprennent une myosite ossifiant localisee et un ischemie digitale post traumatique On observe une hypervascularisation localisee et des zones d obstruction eineuse en rapport avec la myosit ossifiant et avec le retrecissement arteri l

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FROM THE DEPARTMENT OF DIAGNOSTIC RADIOLOGY (DIRECTOR PROF O OLSSON)
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PHARMACOANGIOGRAPHY OF THE LEFT GASTRIC ARTERY IN OESOPHAGEAL VARICES

ANDERS LUNDERQUIST

Roentgenologic examination of hepatic cirrhosis usually comprises (1) barium examination of the oesophagus to demonstrate oesophageal varices, (2) angiography of the coeliac artery to define the liver splenic and portal veins and venous collaterals, (3) pharmacoangiography of the superior mesenteric artery with bradykinin or priscoline to demonstrate the portal vein and venous collaterals, (4) wedge pressure recording in one hepatic vein combined with phlebography with the catheter in the wedge position

Pharmacoangiography of the left gastric artery with bradykinin has also been added to the examination for portal hypertension when the venous collateral circulation in the wall of the fornix of the stomach and lower oesophagus cannot otherwise be demonstrated

Method Selective cathete- tion of the left gastric artery is performed with a catheter (OD 2 2 mm ID 1 4 mm Ten μg bradykinin are injected into the artery followed in 20 to 0 seconds by 30 ml of contrast medium (Isopaque Coronar 370 mg I n l at a rate of about 5 ml/s Exposures are then made 1/s at two seconds 2/ ve seconds and one every other second for 8 seconds The vascular dilatati d increased blood flow produced by bradykinin will give high concentr f the contrast medium in the veins draining the stomach and make them ea o observe

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b

Fig 1 Sixty three year old woman with hepatic cirrhosis and oesophageal arices suggested by barium examination) Coeliac angiography enous phase Filling of splenic and portal eins upper part of inferior mesenteric ein (→) and an omental ein from the hilum of the spleen Short gastric eins and coronary ein remain unfilled b) Pharmacoangiography with bradykinin of superior mesenteric artery enous phase Linear inflow of blood from splenic ein into portal ein No collaterals filled



Fig 2 Same case Pharmacoangiography with bradykinin of left gastric artery enous phase Dilated tortuous eins in the form of the stomach and lower oesophagus are filled

Discussion

Lienoportal phlebography has been almost abandoned in the roentgen examination of hepatic cirrhosis and portal hypertension during the last few years Selective injection of a large amount of contrast medium into the coeliac or splenic arteries and pharmacoangiography of the superior mesenteric artery with bradykinin or tolazoline will usually render evaluation of the splenic and portal veins and their collaterals possible

Lienoportal phlebography with a rather high frequency of complications may be left to the few occasions where the arteriographic examination cannot produce all the information necessary for operation Investigations have indicated that intrasplenic arterial an urysms are overrepresented in patients subjected to percutaneous splenic porto ph y This further stresses the value of arterial portography Moreover even t enoportal phlebography unfavourable flow and layering of the contrast me m may mask collaterals

Where oesophage l an sometimes been suggested at barium examination in hepatic cirrho r d tal hypertension it has been impossible to demonstrate these with r ography (Fig 1) Selective pharmacoangiographic examinat or n stric artery with bradykinin produced filling of

dilated tortuous veins with contrast medium of high concentration and excellent demonstration of oesophageal varices (Fig 2) The reason for non filling of the oesophageal varices at angiography of the coeliac and superior mesenteric arteries must be layering of the medium to more dorsal parts of the splenic and portal veins When the venous collaterals arise from the ventral part of these main stems blood without contrast medium will pass through the venous col laterals towards the oesophagus the oesophageal varices probably cannot then be demonstrated even by lienoportal phlebography

The high concentration of the contrast medium in the collateral veins from the stomach during pharmacoangiography of the left gastric artery with brady kinin will presumably make this method useful even to demonstrate bleeding from oesophageal varices through extravasation of the medium

SUMMARY

Pharmacoangiography f the left gastric artery with bradykinin has been used to de monstrate oesophageal varices The method which is described and discussed may further reduce the need for lienoportal phlebography in portal hypertension

ZUSAMMENFASSUNG

Die Pharamakoangiographie der linken Magenarterie mit Bradykinin wurde erwendet um Oesophagusvarcen nachzuweisen Die Method die beschrieben und diskutiert w rd mag die Notwendigkeit einer lienoportalen Phlebographie bei einer portalen Hypertension weiter erringern

RÉSUMÉ

L angiographi de l artere gastrique gauche dont le comportement avait et modifie par la bradykinine a servi mettre en evidence des varices oesophagiennes Cette methode q est decrit et etudiee peut reduire encore les indications de la phlebographie splenoportale dans l hypertension portale

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FROM THE RADIOLOGIC CLINIC (DIRECTOR PROF J HOLY) AND SURGICAL CLINIC I (DIRECTOR PROF J UHLIŘ) BRNO CZECHOSLOVAKIA

FUNCTIONAL ISOTOPE PHLEBOGRAPHY OF LOWER EXTREMITIES

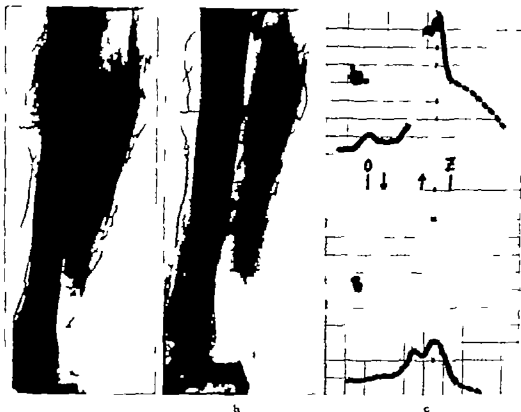
J VITEK A HUVAR and F VRUBEL

Isotope arteriography in which a small amount of isotope was injected intra arterially in obliterative diseases of the lower extremities has previously been described (VITEK et coll 1967) Since then a similar isotopic method has been employed in the investigation of the normal system as well as the occluded or otherwise diseased venous system of the lower extremity

This distinction proved impossible to assess from the speed of the venous flow in a patient standing for although marked individual differences were apparent the difference in the average circu[illegible] time of the individual groups of assessment was negligible The conclusion [illegible] thus reached that only curves representing the dynamic function [illegible] venous system with various diseases will prove of real value The method is [illegible] d functional isotope phlebography

Methods A vein on th[illegible] d[illegible] of the unloaded foot with the patient standing is injected with 10 [illegible] physiologic saline containing 25 μCi of [131] I labelled

Submitted for pub[illegible] F[illegible]bruary [illegible]



F g 1 Functional phlebography) after the injection of contrast medium and b) during the muscular contraction when the medium is being emptied) Isotope phlebogram Activity rises rapidly when the extremity is being loaded sharp fall in activity during contraction of muscl pump when isotope is washed out (In all curves shank probe is marked b and thigh probe Curve read from right to left Phases of exercise = the extremity loaded ↑ = weight on toes ↓ = stepping back on sole 0 = extremity unloaded)

serum albumin The patient then simulates walking by repeatedly transferring his weight to the extremity under examination and stepping lightly on the tip of the toes, back onto the sole, and then transferring the weight to the sound leg Curves were obtained by two probes of a Duovigraph ACEC with the shank probe at the lower margin of the triceps and the thigh probe above the upper margin of the patella Patients had rehearsed the procedure and were instructed not to move away from the probes Values used sensitivity $3\ 10^4$ or 10^5 time constant 0 03/s, speed of paper feed 1 cm/s Thirty patients mostly with varicosities were examined

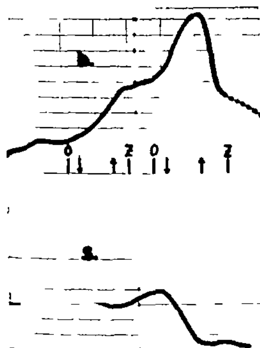


Fig 2 Isotope phlebogram of normal venous system

Results

Fig 1 a and b depict functional phlebography in a normal venous system a single muscle contraction nearly empties the whole system Fig 1 c is of the corresponding isotope curve The shank probe is marked b and the thigh probe a The curves should be read from right to left Each phase of the walk is marked z = extremity loaded ↑ = pressure on toes ↓ = back onto sole 0 = extremity unloaded Loading o the extremity produces a rapid rise of activity in the shank probe while the pump contraction of the muscle causes a rapid fall following the wash out of the isotope The thigh probe indicates constant conditions Th system mptied ithin one exercise

The curve of a r rmal enou system with the same phases (loading and muscular con ra ion) are presented in Fig 2 Emptying takes place after two steps Simila curve presenting good function are always obtained when the varicosities re o oo large and with a normal deep system Two phases of functional phlebo phy appear in Fig 3 (a) filling in the unloaded extremity (b) muscular o traction (con a t medium forward in the deep system



Fig 5 Functional phlebogram a) Filling in an unloaded extremity b) muscular contraction movement of contrast medium in deep system with disappearance of filling of muscle vein)) Extremity unloaded with corresponding disappearance of medium and refilling of muscle veins

centrally and filling of muscle veins disappearing) (c) unloading with disappearance of the medium and a further filling of the muscle veins The corresponding isotope curve is almost that of a normal function curve (Fig 4) It differs only in a slight fresh rise in activity after the extremity has been loaded i e in the flow of activity from the peripheral reservoir The shank system is emptied after three steps

Fig 5 a is of an entirely different curve Irregular oscillation of activity with slow emptying without typical phases of a normal function is evident The deep system is entirely occluded in the contrast phlebogram (Fig 5 b c) the patient suffered from acute phlebothrombosis with swelling of the whole extremity

In the following patient the curve is atypical with minimal emptying appearances (Fig 6 a) A more substantial decline took place only after 50 s of

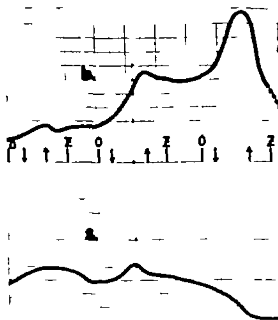
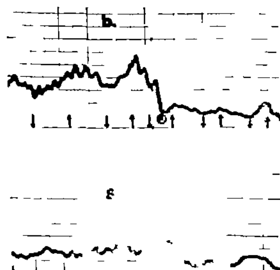


Fig 4 Same case Isotope phlebogram The curv resembles that of normal enous sy tem but the re flov of activ ty from peripheral reservoir causes f ther slight rise in activity fter the extremity has been loaded





b

Fig 5) Iso am rt ctivity oscillat on with slow emptying w thout typ cal phases of no (le t rise in sensitivity of probes) Phlebograms in b) p and) lateral p complete sion of deep system

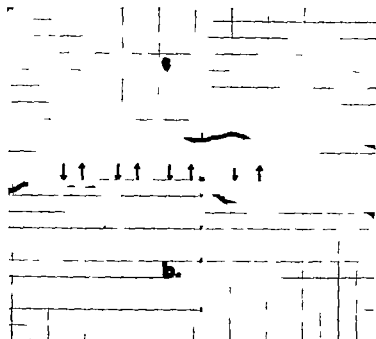


Fig 6a



Fig 6b

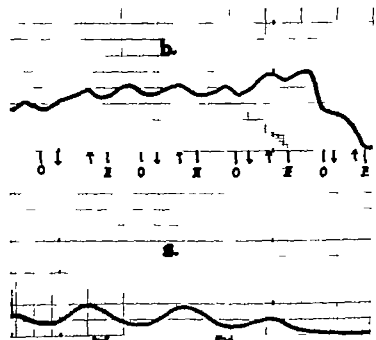


Fig 7

Fig 6 a) Isotope phlebography Atypical curve with minimal emptying Patency of the deep system and normal mechanism of muscle pump absent b) Large haemangiomatous cavernous malformations in calf muscles

Fig 7 Isotope phlebography Characteristic double hunch caused by further rise in activity following each loading but even loading of extremity the suction phase Slow total decline of activity



Fig 8 Same case Functional phlebography) Filling in the unloaded leg b) muscular contraction) Repeated unloading with minimal disappearance of the contrast medium d) after fiv steps Considerable residue of contrast medium

exercise This points again to an occlusion of the deep system and absence of the normal mechanism of a muscle pump, in this instance as a result of a large haemangiomatous cavernous malformation in the calf muscles with an atypical draining vein (Fig 6 b)

Fig 7 depicts the thi d type of curve Its characteristic is a double hunch brought about by a furth r rise in activity after each loading as well as unloading of the leg i e in the ... ct on phase The general decline in activity is slow each muscular contr t n being accompanied by a decline The venous system as a whole is insuffi i nt w h th deep system is patent Corresponding phlebograms appear in Fig 8 filling of an unloaded extremity (b) contraction (c) fresh unloading w h minimal disappearance of contrast medium (d) after five steps with a ... d r bl ... ontrast residue

Functional isotope phlebography is a reliable means of depicting the function of the venous system of the lower extremity and can distinguish between its normal function and insufficiency This can be effected with greater sensitivity than contrast phlebography in which the appearances are disfigured by spe cifically heavy contrast media However it cannot distinguish between the causes of insufficiency i e whether the latter is produced only by varicosities and in sufficient perforators or by the insufficiency of the deep venous system Func tional isotope phlebography may demonstrate occlusion of the deep venous system but not its cause

SUMMARY

Functional isotope phlebography is a method of assessing normal or insuff cient function f the venous system of the leg The procedure was applied in 30 patients predominantly suffering from varicosities Three types of functional curves hav been assessed these corre spond t normal and insufficient function of the venous system as a whol and will reveal occlusion when present

ZUSAMMENFASSUNG

D e funktionelle Isotopenphlebographie ist eine Methode um eine normal oder insuffi ziente Funktion des Venensystems des Beines abzuschatzen Das Verfahren wurde bei 30 Patienten die hauptsachlich an Krampfadererkrankungen litten verwendet Drei Typen von funktionellen Kurven wurden festgestellt diese entsprechen einer normalen oder insuffizien ten Funktion des Venensystems als ganzes und laßt eine eventuell orhandene Okklusion er kennen

RÉSUMÉ

La phlebographi isotop que fonctionnelle est une method pour determiner l fonc tionnement normal ou insuffisant du systeme veineux du membre inferieur Cette technique et appliq ee chez 30 malades souffrant principalement d arices Les auteurs ont trouv 3 types de courbes fonctionnelles elles correspondent une fonction normal et in suffisante du systeme eineux dans son ensemble et montreront une occlusion si lle exist

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SCINTIGRAPHY OF THE PARASTERNAL LYMPHATICS IN THE RABBIT USING TECHNETIUM 99m SULFIDE COLLOID

L R GORANSON and K JONSSON

The parasternal lymph nodes form one of the main drainage areas of the breast TURNER WARWICK (1958) has shown that 75 per cent of the lymph flow from the breast goes to the axillary lymph nodes, while the remaining 25 per cent goes to the parasternal lymphatic The clinical importance of this fact has been documented by ANDREASSEN et coll (1954) who found that 1/3 of the medially located breast carcinomas and 1/10 of those laterally located had parasternal lymph node metastase

It is important to know the spread of a malignant tumour preoperatively in order to modify the operation and the irradiation techniques The axillary lymph nodes can be examined by direct form lymphography for the parasternal lymph nodes, no direct lymphographic technique is available but radioactive tracer

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techniques have been described (ROSSI & FERRI 1966 DIETHELM et coll 1967 SCHENK 1966) These authors used ^{198}Au colloid injected subcutaneously on both sides of the xiphoid process or in the midline behind the process The locally absorbed radiation dose is however very high when ^{198}Au-colloid is deposited locally (HAUSER et coll 1969 HERTING et coll 1970) and radiation necrosis at the site of injection has been reported (HAAS et coll 1970)

Lymph scintigraphy of the retroperitoneal lymph nodes has been successfully performed using ^{99}Tc^{m} S colloid (HAUSER et coll 1969 FAIRBANKS et coll 1972) The locally absorbed radiation dose is much lower as compared to ^{198}Au colloid and there is no risk of local radiation necrosis

The purpose of this investigation was to ascertain whether ^{99}Tc^{m} S colloid injected subcutaneously can be used for scintigraphy of the parasternal lymphatics, and if the resorption of the colloid depends on or is enhanced by hyaluronidase

Material and Methods The rabbits used for the experiments weighed between 1 5 and 3 0 kg They were anaesthetized with intravenous Pentobarbitone sodium (Mebumalnatrium ACO Sweden) and the upper part of the abdomen around the xiphoid process was shaved with an electric razor

The ^{99}Tc^{m} S-colloid was prepared according to PERSSON & NAVERSTEN (1970) The mean size of the colloid particles was estimated to be 0 7 $\pm$ 0 3 μm The physical half life of ^{99}Tc^{m} is six hours, and the measurements are performed with pulse height analyses in the energy interval 119/161 keV After injection of the colloid the animals were placed in supine position under a 4 000 channel or a pinhole collimator of a gamma camera (Nuclear Chicago Pho Gamma III)

In group I consisting of 10 animals 250 μCi of ^{99}Tc^{m} S colloid were injected subcutaneously on each side of the xiphoid process The volume of each injection was 1 ml No local anaesthesia was given before the injection In group II consisting of 11 animals the same amount of colloid and the same technique were used as in the first group except that 100 IU hyaluronidase (Hylas Leo Sweden) was injected subcutaneously two minutes before the injection of the colloid The volume of hyaluronidase for each injection was 1 ml The third group consisted of 11 animals and they were injected on both sides of the xiphoid process with 250 μCi ^{99}Tc^{m} S-colloid concentrated to a volume of 1/2 ml, and 100 IU hyaluronidase was dissolved in the concentrated colloid

The uptake of colloid in the lymph nodes was recorded for periods of 15 to 120 minutes by the Intertechnique system of cine scintigraphy used with the Nuclear Chicago Pho Gamma III

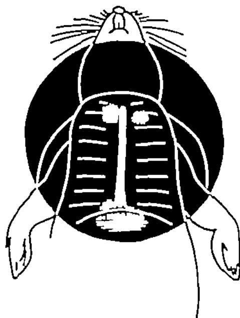


Fig 1 Distribution of radioactive colloid in a rabbit from Group III 2 to 15 minutes after injection The site of injection is seen in the upper part of the abdomen Lymph nodes evident in the upper mediastinum on both sides of the midline

Results

No lymph nodes in the intercostal spaces were detected in any of the animals

Two groups of lymph nodes are located in the upper mediastinum one on the right side and one on the left side filled from parasternal lymphatics on the respective sides The presence of normal parasternal lymph flow was assumed when these lymph nodes were filled with the isotope

In group I where only $^{99}Tc^{m}$ S colloid had been injected, uptake in the upper mediastinal lymph nodes occurred in only four animals on both sides of the midline in one and on only one side in the remaining three The uptake was faint and could first be detected after one hour

In group II where the injection of radioactive colloid was preceded by hyaluronidase bilateral filling of the upper mediastinal lymph nodes occurred in six animal [illegible] thin 2 to 25 minutes In four animals no lymph nodes were detected and in one animal the colloid at the site of injection had spread out on the chest w[illegible]l an[illegible] no lymph nodes could be identified

In group III where the animals were injected with concentrated colloid mixed with [illegible]uronidase the upper mediastinal lymph nodes were observed bilaterally in [illegible] a[illegible] within 2 to 12 minutes (Fig 1) The colloid uptake in three animal[illegible] as recorded for 120 minutes In this group the resorption and

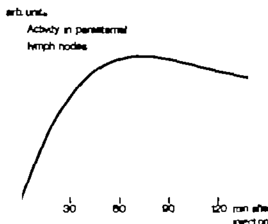


Fig 2 Activity curve in a parasternal lymph node of the upper mediastinum

filling of the mediastinal lymph nodes started almost immediately after injection The activity in the lymph nodes increased linearly for 60 to 80 minutes then reached a plateau or decreased slightly (Fig 2)

Discussion

The lymph flow from the breast and the lymphatic spread of carcinoma of the breast has been given much attention in the literature HULTBORN et coll (1955) showed with an isotope technique that the lymph flow from all parts of the breast goes to both the axillary and the parasternal lymph nodes TURNER WARWICK (1958) concluded that 75 per cent of the lymph flow from the breast goes to the axillary nodes and 25 per cent to the parasternal nodes The clinical importance of this fact in patients with carcinoma of the breast has been demonstrated by ANDREASSEN et coll (1954) and URBAN & MARJANI (1971) The latter authors found parasternal lymph node metastases in 33 per cent of 725 extended radical mastectomies The possibility of preoperatively diagnosing parasternal lymph node metastases has so far been rather limited A method for the biopsy of these nodes (HANDLEY & THACKRAY 1949 1954) appears to have only limited practical use, although the results reported are excellent KETT et coll (1970) have described a method of direct lymphography of lymph vessels of the breast The technique is difficult, and seems to have limited value for the parasternal lymphatics

MASSOUD et coll (1964) have reported a series of 66 patients where they performed tomography of the anterior mediastinum, in most cases in combination with induced pneumomediastinum the smallest lymph node metastases found had a diameter of 0 6 cm

Transternal phlebography for detection of parasternal lymph node metastases can be employed but the results obtained are only reliable for the first and second intercostal space (CHERNOMORDIKOVA et coll 1972) The most common diagnostic method for detecting parasternal lymph node metastases seems to be lymph scintigraphy first described independently in 1966 by DIETHELM et coll ROSSI & FERRI and SCHENK Their technique, in some cases with slight modifications has later been used by other authors SCHENK et coll (1966) ROSSI et coll (1968) MICHAILOV et coll (1968) KAZEM et coll (1968 1969) SEIFERT & BETZNER (1970) and MEYER BURO & WILHELMI (1971)

GROS et coll (1972) injected the ^{198}Au-colloid on the dorsum of both hands, in the axillary line of the 7th intercostal space and in the midline behind the xiphoid process for a total evaluation of the lymph drainage of both breasts Lymph node scintigrams have been performed 24 to 48 hours after injection of the colloid in all these investigations In case of metastases, the parasternal lymph nodes do not fill with the colloid Due to poor resolution, no details of the individual lymph nodes can be detected Wide normal variations in the anatomy of the lymph nodes in the parasternal region (STIBBE 1918) also make the interpretation difficult

Although ^{99}Tc^{m} S colloid has been used for scintigraphy of the retroperitoneal lymph nodes (HAUSER et coll 1969 FAIRBANKS et coll 1972) it has not been used for scintigraphy of the parasternal lymph nodes with subcutaneous injection of the colloid ATKINS et coll (1970) reported one case of filling of mediastinal lymph nodes in man following intraperitoneal injection of ^{99}Tc^{m} S colloid It has also been used experimentally for examination of the parasternal lymphatics after intraperitoneal injection (GORANSON et coll 1973) The colloid is resorbed through lymph vessels in the diaphragm to the parasternal lymphatics However this transabdominal injection technique requires fluoroscopy in order to control the position of th needle and to ensure that the injection is made in the free peritoneal cavity / a subcutaneous injection of h colloid undoubtedly is much simpler for the patient the t hnique with ni ion of the technetium colloid on both sides of the xiphoid process was tried

As expected the resorption of the colloid was nhanced by hyaluronidase (first used in clinical practice by OLSSON & LO GREN in 1949) This has been pointed out in al p evious reports on lymph sc tigraphy with the exception of KAZEM et coll (9) The colloid was resorbed very slowly when hyaluronidase was no ed, resulting in only faint uptake of the isotope in the upper mediastin l ly ph nodes in a few animals

The best way to us he hyaluronidase was o dissolve it in the colloid before injection in the cut Hyaluronidase is highly soluble in the colloid and the volume injected can be kept to a minimum This procedure also ensures that the

hyaluronidase and the colloid are injected at exactly the same spot. When the hyaluronidase is injected before the technetium colloid, the two solutions may be injected at different levels of the cutis, and no enhancement of the resorption will occur. Another disadvantage is that the volume injected will be greater, as the hyaluronidase must be separately dissolved in saline. A third disadvantage with a greater injection volume is that the radioactive substance easily flows out, and after a short while is spread out over a large area of the upper abdomen and the chest wall, thereby covering the lymph nodes.

No intercostal lymph nodes could be identified in the rabbits, in contrast to the published reports of parasternal lymph scintigraphy in man. This was also found in a previous report (GORANSON et coll. 1978). It is not certain whether this is due to the minute size of the lymph nodes in the rabbit or if these lymph nodes are absent in the rabbit.

When the colloid and hyaluronidase are mixed together, the uptake in the lymph nodes shows an almost immediate and linear increase. Maximum is reached after 60 to 80 minutes, followed by a steady state or by a slight decrease depending on the biologic and physical decay of the technetium colloid. To obtain maximum information it is necessary to follow the uptake for about 1 1/2 hours, although the question of filling versus non filling is answered within half an hour or less.

The method is planned to be used in man, and if the experimental data are applicable, the results of the examination are obtained much sooner with ^{99m}Tc-S colloid than with ^{198}Au colloid.

Acknowledgement

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SUMMARY

Parasternal scintigraphy with ^{99m}Tc-S colloid has been performed in rabbits. The colloid was injected on both sides of the xiphoid process. Hyaluronidase dissolved in the colloid was the most favourable method for enhancing the resorption.

ZUSAMMENFASSUNG

Es wurde eine parasternale Skintigraphie mit ^{99m}T = S Kolloid bei Kaninchen vorgenommen. Das Kolloid wurde zu beiden Seiten des *Processus xiphoideus injiziert*. Hyaluronidase gelöst im Kolloid war die vorteilhafteste Methode, um die Resorption zu erhöhen.

RÉSUMÉ

Les auteurs ont fait sur des lapins des scintigraphies parasternales avec un colloïde ^{99}Tc^{m} S Ce colloïde a été inject des deux cotes de l appendice xiphoïde L hyaluronidase dissoute dans le colloïde est le moyen l plus favorable pour faciliter la résorption

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GRADING OF OSTEOPOROSIS BY SKELETAL ROENTGENOLOGY AND BONE SCANNING

N. DALÉN and B. LAMKE

Osteoporosis may be graded according to various criteria. Skeletal roentgenology makes it possible to determine a large number of morphologic parameters of osteoporosis, while bone scanning enables the amount of bone mineral to be measured in different parts of the skeleton. Since, however, changes in the skeletal morphology and mineral content are not identical criteria of osteoporosis, the results of an investigation may depend upon the method used as well as upon the part of the skeleton examined; the degree of osteoporosis is unlikely to be uniform throughout the skeleton.

The purpose of the present investigation was to compare these two methods in randomly selected subjects, and to examine the relationship between the mineral content and the morphology in different parts of the skeleton.

Methods and Material. The roentgenologic classification was made in accordance with two principles, namely by examination of the trabecular structure and measurement of the cortical thickness of long bones. The trabecular structure of the lumbar spine was graded in a lateral film as described by SAVILLE (1967).

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Tabl 1

Precision (1 SD) of the roentgenologic classification including re filming, and intra-observer errors as obtained from replicate measurements in 16 patients expressed as a percentage of the mean of the values observed at the respective sites

Site		Precision
Trabecular score	Lumbar spine	24 0
	Femur neck	15 0
Outer diameter	Metacarpal bone II	1 9
	Radius	3 1
	Femur	1 5
Inner diameter	Metacarpal bone II	2
	Radius	8
	Femur	6 1

and of the femoral neck in an a.p projection by the method of SINGH et coll (1970) The inner and outer diameters of the cortex at the middle of the second metacarpal bone (BARNETT & NORDIN 1960) of the proximal part of the radius (MEEMA 1963) and of the shaft of the femur (BARNETT & NORDIN 1960) were measured Cortical areas and cortical ratios were calculated by the following formulas cortical ratio $= (D - d)/D$ and cortical area $D^2 - d^2$ $D =$ outer diameter and $d =$ inner diameter

Table 2

Precision (1 SD) of bone scanning as obtained from replicate measurements in 26 subjects expressed as percentage of the mean bone mineral content at the respective sites

Site	Precision
Metacarpal bone II midshaft	1 5
Radius + ulna distal	3.2
Radius + ulna shaft	0 9
Humerus head	2.2
Third lumbar vertebra	10 0
Femur neck	1 9
Femur shaft	2 4
Calcaneus	3 4

Table 3

Morphologic parameters and their standard deviation (SD) for different parts of the skeleton for different sex and age groups expressed as percentages of the mean for the youngest female group. The cortical dimensions are corrected for body size

		Females						Males			
		30–34		45–49		55–59		45–49		55–59	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Lumbar spine trabecular score		100	7	91	20	61	31	94	15	80	31
Femur neck trabecular score		100	12	82	19	66	21	8	24	78	21
Metacarpal bone cortical ratio		100	15	87	14	79	16	84	18	83	13
Radius proximal cortical thickness		100	15	98	16	79	23	95	14	92	16
Outer diameter	metacarpal bone	100	7	103	8	105	8	104	9	102	10
	prox radius	100	10	109	7	101	8	108	9	111	7
	femoral shaft	100	7	106	7	108	8	119	18	124	11
Inner diameter	metacarpal bone	100	32	124	23	14	20	135	27	133	1
	prox radius	100	16	112	12	119	19	119	18	124	11
	femoral shaft	100	16	110	16	108	10	112	17	118	13

Table 4

Bone mineral content corrected for body size and standard deviation (SD) for different parts of the skeleton for different sex and age groups expressed as percentages of the mean for the youngest female group

	Females						Males			
	30–34		45–49		55–59		45–49		55–59	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Metacarpal bone II	100	11	99	9	86	13	108	10	110	12
Radius + ulna distal	100	20	93	20	74	26	112	10	1 0	[illegible]
Radius + ulna shaft	100	10	100	9	86	17	118	9	118	11
Humerus head	100	21	90	23	58	41	113	15	114	19
Third lumbar vertebra	100	15	86	18	61	20	86	15	86	16
Femur neck	100	14	96	15	89	17	109	14	103	13
Femur neck medial part	100	13	101	15	96	13	92	18	89	1
Femur neck central part	100	18	85	19	75	25	83	15	74	16
Femur shaft	100	8	103	12	95	11	108	7	104	15
Calcaneus	100	12	100	15	85	14	105	14	106	15

Tabl 5

Spearman Rank Correlation coefficients between morphologic parameters All coefficients between −0 25 and 0 25 are omitted The values were corrected for age sex and body size before the coefficients were calculated

		Trabecular score		Cortical ratio		
		Lumbar spine	Femoral neck	Mc II	Rad	Fem
Lumbar spine		1 0	0 35	—	—	—
Femoral neck		0 35	1 0	—	—	—
Cortical ratio	Mc II	—	—	1 0	0 34	0 34
	Radius	—	—	0 34	1 0	0 28
	Femur	—	—	0 34	0 28	1 0
Cortical thickness radius		—	0 28	0 37	—	0 33
Inner diam	Mc II	—	—	−0 95	−0 36	−0 35
	Radius	—	—	−0 50	−0 55	−0 53
	Femur	—	—	−0 29	−0 29	−0 86
Cortical area	Mc II	—	—	—	—	—
	Radius	—	0 30	—	−0 30	—
	Femur	—	—	—	—	0 46

The grading of osteoporosis in trabecular bones was based on the following criteria

Lumbar spine — Group 5 Normal bone structure Group 4 End plates begin to stand out Group 3 Vertical striation more obvious Group 2 End plates less visible Group 1 No trabeculae visible

Femoral neck — Group 6 Normal bone structure Group 5 Slight reduction of trabeculae in the central part Group 4 Lateral trabeculae reduced in number the reduction proceeding outward from the center Group 3 Further reduction of lateral trabeculae Group 2 Only medial trabeculae stand out prominently Group 1 Even the medial trabeculae are markedly reduced in number

The precision of the roentgenologic appraisal was determined by replicate determinations in 16 patients at intervals of at least a week All the films were exposed by the same radiographer in the same roentgen unit and were examined by the same radiologist The precision, which included intra-observer and re filming errors, is indicated in Table 1 The results are consistent with those previously reported (MAZESS et coll 1968)

The bone mineral content was determined by roentgen spectrophotometry (JACOBSON 1964 GUSTAFSSON et coll 1974) The method is based on attenua

Table 5 (cont)

Cortical thickness radius	Inner diameter			Cortical area		
	Mc II	Rad	Fem	Mc II	Rad	Fem
—	—	—	—	—	—	—
0.28	—	—	—	—	0.30	—
0.37	−0.95	−0.50	−0.29	—	—	—
—	−0.36	−0.55	−0.29	—	−0.30	—
0.33	−0.35	−0.53	−0.86	—	—	0.46
1.0	−0.30	−0.33	−0.37		0.84	—
−0.30	1.0	0.49	0.28	—	—	—
−0.33	0.49	1.0	0.52	—	—	—
−0.37	0.28	0.52	1.0	—	—	—
—	—	—		1.0	—	—
0.84	—	—	—	—	1.0	—
—	—	—	—	—	—	1.0

tion measurements employing a scintillation detector the attenuation of the soft tissues in the radiation beam was compensated by using two radiation energies The mineral content at a particular site was determined by scanning with a slit beam that was well collimated Measurements were made at eight sites to obtain a representative appearance of the whole skeleton These and the precision obtained appear in Table 2 (cf DALEN & JACOBSON 1975)

A normal population was examined to assess the extent to which the methods enable small differences in osteoporosis to be distinguished The group was drawn at random from Stockholm the proportion of missing subjects totalling 27 per cent The age distribution of the material measured was as follows Women, age 30—34 n = 24 45—49 n = 20 55—59 n = 28 Men, age 45—49 n = 10 55—59 n = 14

Some parameters, such as the mineral content and areas of cortical bone, are dependent on body size, while others such as the grading of trabecular bone and the cortical ratios, are not To make these parameters comparable all the values dependent on body size were divided by the body area as calculated from (height (cm) + weight (kg) — 60)/100

All correlation coefficients except those given in Table 8 were obtained after correction for age sex and body size The corrections for age and sex were

Table 6

Spearman Rank Correlation coefficients between bone mineral content at various measuring sites The values were corrected for age sex and body size before the coefficients were calculated

	Metacarpal bone II	Radius+ulna Distal	Radius+ulna Shaft	Humerus head	Third lumbar vertebra	Femur Neck	Femur Shaft	Calcaneus
Metacarpal bone II	1 0	0 63	0 72	0 52	0 31	0 42	0 30	0 29
Radius+ulna distal	0 63	1 0	0 75	0 62	0 33	0 59	0 33	0 46
Radius+ulna shaft	0 72	0 75	1 0	0 53	0 33	0 45	0 44	0 29
Humerus head	0 52	0 62	0 53	1 0	0 30	0 67	0 31	0 30
Third lumbar vertebra	0 31	0 33	0 53	0 30	1 0	0 4	0 18	0 30
Femur neck	0 4	0 59	0 45	0 62	0 42	1 0	0 51	0 43
Femur shaft	0 30	0 33	0 44	0 31	0 18	0 51	1 0	0 31
Calcaneus	0 29	0 46	0 29	0 30	0 30	0 43	0 31	1 0

made by expressing each value for each subject as the percentage deviation from the mean for the respective age and sex group

Results

The morphologic parameters differed according to sex and age and to facilitate their comparison the values were expressed as a percentage of the mean for the youngest female group The results are presented in Table 3 At ages as low as 45—49 years both sexes displayed morphologic signs of osteoporosis in the form of sparse trabecular structure in the lumbar spine and the femoral neck while females also had wide marrow spaces in the long bones

The mineral content also differed according to sex and age (Table 4) The biologic variation was greater for the trabecular than the cortical measuring sites The lowest values for the bone mineral content in the 55—59 year group of women were recorded for the distal parts of the radius and ulna head of the humerus and the central part of the femoral neck The sex differences for respective age groups were large for the upper extremities but small for the lumbar spine and femoral neck

The coefficients of correlation (BMDP 3S) between the various morphologic parameters were generally low (Table 5) The grading of trabecular structure in the femoral neck was the only parameter significantly correlated ($p < 0 01$) to the estimated degree of osteoporosis of the lumbar spine The coefficients of correlation (BMDP 3S) between the values for the mineral content at the various measuring sites (Table 6) were considerably higher than the coefficients for the morphologic parameters The relationship between these parameters and the bone mineral content appears in Table 7 The mineral content for the

Table 7

Spearman Rank Correlation coefficients between morphologic parameters and mineral content All coefficients between −0 25 and 0 25 are omitted The values were corrected for age sex and body size before the coefficients were calculated

	Metacarpal bone II	Radius + ulna Distal	Radius + ulna Shaft	Humerus head	Third lumbar vertebra	Femur Neck	Femur Shaft	Calcaneus
Lumbar spine trabecular score	—	0.27	—	0.33	—	0.29	—	—
Femur neck trabecular score	—	0.45	0.25	0.30	—	0.33	—	0.35
Metacarpal II cortical ratio	0.26	0.30	—	—	—	—	—	—
Radius cortical ratio	—	—	—	—	—	—	—	—
Femur cortical ratio	—	—	—	—	0.[illegible]5	0.29	0.43	—
Radius cortical thickness	0.51	0.48	0.58	0.34	—	0.40	0.3	—
Metacarpal II cortical area	0.63		0.37	—	—	—	—	—
Radius cortical area	0.51	0.47	0.60	0.43	—	0.56	0.27	—
Femur cortical area	—	—	—	—	—	0.28	0.53	—

trabecular measuring sites in the distal parts of the radius and ulna, the head of the humerus and the femoral neck are correlated to some extent with the trabecular structure in the lumbar spine and femoral neck A fairly close correlation between the cortical area and the bone mineral content of the second metacarpal bone was evident (cf VIRTAMA & MÄHÖNEN 1960)

Table 8

Spearman Rank Correlation coefficients between morphologic parameters mineral content and age for females The morphologic parameters and the mineral content were not corrected for age

	Metacarpal bone II	Radius + ulna Distal	Radius + ulna Shaft	Humerus head	Third lumbar vertebra	Femur Neck	Femur Shaft	Calcaneus	Years
Lumbar spine trabecular score	0.42	0.64	0.47	0.68	0.50	0.5	—	0.41	−0.76
Femur neck trabecular score	0.47	0.62	0.41	0.62	0.48	0.50	—	0.43	−0.76
Metacarpal II inner diam.	−0.[illegible]6	−0.41	−0.25	−0.40	—	−0.35	—	—	0.54
Radius inner diam	—	−0.[illegible]9	—	—	—	−0.30	—	—	0.44
Femur inner diam	—	—	—	—		—	—	—	0.29
Years	−0.47	−0.53	−0.37	−0.65	−0.47	−0.44	—	−0.41	1.0

Trabecular bone presented a greater correlation with age than cortical bone This is evident in Table 8 in which the correlation between morphologic parameters bone mineral content and age for the female group is given

Discussion

The morphologic findings (Table 3) are consistent with what is known of the occurrence of osteoporosis in various sex and age groups Both microradiography and autopsy have indicated that osteoporosis is of early onset, probably developing by the fourth decade in both sexes (LINDAHL & LINDGREN 1962 JOWSEY et coll 1965) In one of the few longitudinal investigations performed, GARN et coll (1967) have reported that cortical bone is remodelled by endosteal resorption and periosteal apposition, a process that results in an increase in the inner and outer diameters with age

The reduction in the mineral content with age was greater in trabecular than in cortical bone The oldest female group had particularly low mineral contents in the distal parts of the radius and ulna, the humeral head and the central part of the femoral neck these sustain a high incidence of fractures (ALFFRAM & BAUER 1962 ALFFRAM 1964) Another agreement between fracture epidemiology and bone mineral content is evident from the sex differences observed Consequently men have comparatively less fracture incidence in the distal part of the radius than in the femoral neck as compared to females the sex differences in bone mineral content (Table 4) may explain these differences in bone brittleness

The morphologic parameters and the bone mineral content did not always correspond For instance, the inner diameter of the long bones increased considerably with age but the differences in their mineral content in the various age groups were small (Tables 3 4) One possible explanation of this discrepancy between the morphologic evidence of bone loss and the decrease in the bone mineral content is that endosteal resorption is to some extent compensated for by periosteal apposition The latter results in an increase in the outer diameter and a reduction in the amount of bone mineral per unit of anatomic volume even when the mineral content remains unchanged

The choice of a measuring site is of importance This is illustrated by the bone mineral content of the femoral neck recorded whereas the changes with age were small for the medial cortical part, they were considerable for the central trabecular part

The coefficients of correlation between the various morphologic parameters were generally low It is consequently at most sites difficult to estimate the grade of osteoporosis from morphologic observations at another site The grading

of trabecular structure in the femoral neck was the only parameter significantly correlated ($p < 0.01$) to the estimated degree of osteoporosis of the lumbar spine.

Certain trends may be discerned in the correlations between the bone mineral content for the various measuring sites (Table 6). For example, the closer the sites were to each other the greater the correlation. Moreover, the trabecular bone measurements agreed with one another and the cortical bone measurements had a tendency to correlate internally; this is consistent with the results of NORDIN (1968). The bone mineral content of the third lumbar vertebra, however, would seem to constitute an exception, but here the major part of the mineral content of the vertebra is accounted for by the transversal and spinous processes which contain a greater proportion of cortical bone than the body; spondylosis may also be a significant factor.

The mineral content in the trabecular parts of the skeleton had the greatest correlation with morphologic signs of osteoporosis, as indicated by sparse trabecular structure in the axial skeleton and wide marrow spaces in the appendicular bones (Tables 7, 8).

Acknowledgement

This work was supported by a grant from the Swedish Medical Research Council.

SUMMARY

An investigation of randomly selected subjects by skeletal roentgenology and bone scanning revealed that the mineral reduction with age was greater in trabecular than in cortical bone. The amount of mineral in the oldest female group was especially low in parts of the skeleton with a high incidence of fractures (distal part of radius, proximal part of humerus and the femoral neck). The mineral content of these sites had the greatest correlation with morphologic signs of osteoporosis.

ZUSAMMENFASSUNG

Eine Untersuchung zufällig ausgewählter Personen mit Röntgenuntersuchung des Skeletts und Knochenabtastung ergab, dass die Abnahme an Mineralien mit dem Alter stärker im trabekulären Knochen als im kortikalen Knochen ausgeprägt war. Der Mineralanteil in der ältesten weiblichen Gruppe war besonders in den Teilen des Skeletts niedrig, bei denen das Vorkommen von Frakturen hoch ist (dem distalen Teil des Radius, dem proximalen Teil des Humerus und dem Femurhals). Der Mineralgehalt dieser Gebiete zeigte die höchste Korrelation zu den morphologischen Zeichen einer Osteoporose.

RÉSUMÉ

Un tra ail fait sur des sujets choisis au hasard effectue par radiographie du squelette et par scintigraphie osseuse a montre que la reduction du contenu mineral en rapport avec l age est plus grande dans l os trabeculaire que dans l os cortical La teneur en mineraux dans le groupe des femmes les plus agees etait particulièrement faible dans les parties du squelett qui presentent une grande frequence de fracture (la partie distal du radius la partie proximale de l humérus et le col femoral) La teneur minerale de ces regions presentait la plus grande correlation avec les signes morphologiques d osteoporose

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INSTRUMENT FOR ISOTOPE DETERMINATION IN VIVO OF MINERAL CONTENT OF THE JAW BONE

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Advanced photodensitometric methods for the roentgenographic determination of the mineral content of bone were published by Engström & Welin (1949), Omnell (1957) et alios. Transmission measurement from an isotope by direct photon absorptiometry has recently come into increasing use and provided for greater precision and accuracy than previously. The isotope I was introduced as a radiation source for diagnosis by Bergonius et coll. (1962); this isotope was also employed by Cameron & Sorensen (1963) to determine the quantity of bone mineral. Since then a large number of determinations of bone mineral have been reported; other isotopes have also been employed (Schmeling 1972). Henrikson (1967) described how measurements of high precision may be made of bone mineral in the jaws by fixation of the source of radiation to the teeth. A device for this purpose was developed by Henrikson & Julin (1971).

The object of the present work has been to design an instrument for the quantitative measurement of bone mineral in the jaws and alveolar processes, the determination of the jaw thickness being made during the transmission

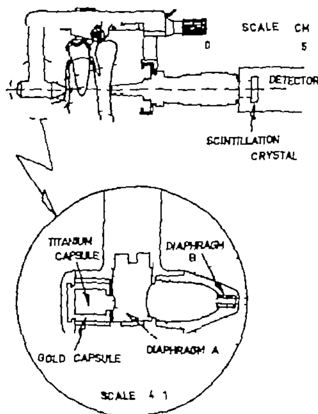


Fig 1 Drawing of the instrument with enlarged section of the capsule containing isotope and diaphragm system

measurement without disturbance of the latter by saliva, fluctuating swellings or mobile mucosa The device had also to offer the means of identifying the area of the transmission measurement so as to make it possible to assess the relationship of the measurement to surrounding anatomic structures in a roentgenogram

Method The attenuation of roentgen radiation through bone and soft tissue is caused partly by bone minerals and partly by protein, fat and water Disregarding the small fat component it may be assumed that—apart from the bone mineral—attenuation takes place mainly in protein and water the linear attenuation coefficient of which has been given by HENRIKSON & JULIN (1971) as 0 45 cm $^{-1}$ at a radiation energy of 27 4 keV (I) in gingivae The linear attenuation coefficient for the bone mineral constituents was reported by the same authors to be 9 4 cm $^{-1}$

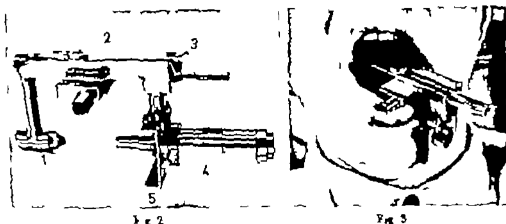


Fig 2 Fig 3

Fig 1) Capsule with isotope rotatable diaphragm A and fixed diaphragm B 2) Base for buccolingual and mesiodistal movement with micrometer screws 3) Operating lever for rotatable diaphragm A 4) Micrometer screw for thickness measurement and connection to detector 5) Film holder

Fig 3 The instrument in situ for exposure of film

The transmission formula may be expressed as

$$T = \frac{I_1}{I} = e^{-[\mu_{BM} x + \mu_{ST}(l - x)]}$$

where T = the transmission
I_0 = the flow of photons into the object
I_1 = transmitted flow of photons
e = the base of the natural logarithm system
μ_{BM} and μ_{ST} = linear attenuation coefficients for bone mineral and soft tissue (cm^{-1})
l = total thickness of the object (cm)
x = thickness of hydroxy apatite

If the linear attenuation coefficients for the given radiation energy are known three values are required for determination of bone mineral (1) Flow of photons in front of the tissue, I_0 (2) transmitted flow of photons I_1 and (3) total thickness of tissue l Correction for the effect on the attenuation coefficient caused by small amounts of radiation of energies other than the major part of the radiation is done after the recording of the spectrum for the radiation source and the construction of a correction curve (HENRIKSON & BERGSTRÖM 1973)

The flow of photons from a well collimated narrow beam may be counted with a detector analyser counter system A device has been constructed with a holder for the isotope and diaphragm system and permitting measurement of thickness



Fig 4 Portion of ... measured



Fig ... The instrument in ... with the detector connected

by means of a micrometer screw (Figs 1 2) The instrument consists of three main parts (1) Capsule with isotope and diaphragm system (2) base moved by micrometer screws in buccolingual and mesiodistal directions, (3) film holder and micrometer screw for measurement of thickness The capsule and film holder with micrometer screw are rigidly secured to the base

The capsule contains an isotope, e g [1] I electrolytically precipitated on the tip of a silver or copper electrode of 0 5 mm diameter (Bergstrom et coll 1962, 1972) (This isotope is supplied by AB Atomenergi enclosed in a titanium capsule 3 mm ⌀ and 4 mm long) The titanium capsule is enclosed in a gold shield with screwcap and with a window open in the direction of the beam thin radiation filters, e g of tin may be inserted in the window The gold shield is enclosed in the instrument capsule with another screwcap A rotable diaphragm A lies in front of the window in the direction of the beam this has three settings, a first setting with a large aperture for exposure of the film and a second setting to produce a small aperture at 90 to the large aperture for the transmission measurement The latter aperture produces a beam slightly wider than the inner diameter of diaphragm B which thus determines the diameter of the beam from the instrument capsule Diaphragm B is fixed to the instrument capsule with a plastic cone The distance from the isotope to the tip on the plastic cone is 16 mm Diaphragm B on exposure of the film appears as a ring round the area measured (Fig 1) The rotatable diaphragm A of gold has an intermediate setting between the two mentioned at which the beam is entirely cut off This diaphragm ... controlled by an ... rating lever outside the oral cavity (3 Fig 2)

The photons ha... d the object ... examination reach the cassette holder and microm... w for me... t of the thickness of the jaw

On exposure of film a bayonet socket enables the micrometer screw to be removed (Fig 3) The base is screwed buccolingually for the transmission measurement so that the plastic cone at diaphragm B is applied to the tissue lingually A probe with a thin plastic window is then screwed against the tissue buccally so that the total thickness of the tissue may be read directly on the micrometer screw The size of the plastic window is so adjusted as to contain the entire beam The transmission measurement is thus made, the detector being brought up against a guide ring at the far end of the hollow micrometer screw (Fig 5)

A silver splint to which is fixed a plate with two pins attaches the device to the jaw (Henrikson 1967) The isotope capsule is sealed against the entry of liquid, e g saliva The device is mostly of stainless steel with teflon bushings and seals Autoclaving is possible the isotope with the gold capsule should first be removed through the screwcap in the rear end of the capsule followed by the plastic cone with diaphragm B and the plastic window in the probe The plastic cone and window are attached by means of conical seatings

Discussion

The instrument has been based on the same principles as those described by Henrikson (1967) and Henrikson & Julin (1971) The latter stated that the thickness measurement was done by bringing the buccal and palatinal windows of the device, spaced at a fixed distance from one another up against the tissue one at a time so that its total thickness might be calculated This procedure assumes that the measurement be made against firm gingiva or mucosa on each side and that saliva will cause no impediment to the beam the measurement must therefore be made in areas of firm mucosa and after careful air drying

The present device was constructed for measurements also of the lower jaw where accumulation of saliva mobile mucosa and if therapeutic measures have been taken fluctuating swellings may occur Thin plastic windows applied to the mucosa on each side during the measurement help to prevent these factors affecting the result Swellings of the soft tissue may be displaced with the windows so that in repeat examinations a constant thickness of object may be obtained despite the disappearance or fluctuation of the swellings

As the radiation from [illegible]I may also be used for roentgenography the instrument was constructed to allow the production of roentgenograms [illegible] diaphragm marks the exact area used for the transmission measurement This permits a reliable assessment of the area of the bone mineral measurement and of its situation in relation to surrounding anatomic structures

Acknowledgement

The authors are greatly indebted to Dr Sevald Forberg for his help during the work

SUMMARY

A device for measurement of the bone mineral in the jaws is described The transmission f a narrow beam of radiation from an isotope is measured Windows applied to the mucosa on both sides f the object permit the determination of thickness to be mad without disturbance from saliva or mobile tissue Roentgenography of the region under examination is made possible and is a feature of the instrument

ZUSAMMENFASSUNG

Ein Anordnung zur Messung des Knochenmineralgehalts der Kiefer wird beschrieben D e Transmission eines feinen Strahls der Strahlung on einem Radionuklead wird gemessen Fenster di an die Mukosa zu beiden Seiten des Objekts angebracht werden ermoglichen es die D cke ohne Storung durch Speichel oder bewegliches Gewebe zu messen Die Rontgen untersuchung der Region wahrend der Untersuchung ist moglich und ein Merkmal des Instruments

RÉSUMÉ

Description d un dispositif de mesure du contenu mineral de l os des maxillaires On mesur la transmission d un etroit faisceau du r yonnement d un radionuclid Des fenetres appliquees à la muqueuse sur les deux faces d l objet permettent de determiner son epaisseur sans erreur due à la salive ou aux tissus mobiles La radiographie de la region examinee est possibl e est une des caracteristiques de cet instrument

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ANGIOGRAPHY IN GASTRIC TUMOURS

F Efsen and K Fischerman

The detection of gastric malignancy has for many years constituted a challenge calling for many different procedures For the early diagnosis, the conventional barium meal is improved by the double contrast investigation and gastroscopy including biopsy is now well established Selective angiography of the coeliac and superior mesenteric arteries have also contributed to the diagnosis (Boijsen et coll 1966) selective angiography of the left gastric artery has been discussed by Svendsen (1970) who stressed its value in small lesions

The present investigation was carried out in order to compare the results of angiography with those of surgery as regards the size of the tumour and its resectability the vascular appearance of the process was also compared to the histologic type

Material and Methods The series comprised 15 consecutive patients aged from 44 to 82 (average 63 years) with gastric carcinoma Before angiography malignancy had been diagnosed by a conventional barium meal including the double contrast method Gastroscopy with biopsy as well as the pentagastrin test were carried out if technically possible

Submitted for publication 6 July 1973

Table 1

Resectability and angiographic findings in 15 cases of gastric carcinoma. Figures indicate number of cases with positive angiographic findings

	N of cases	Angiographic findings									
		Coeliac art					Superior mesenteric art				
		A	B	C	D	E	A	B	C	D	E
Resectable	7	4	3	7	6	4	1	2	2	1	0
Non resectable	6	1	4	3	5	2	0	0	1	0	1
No operation	2	0	0	0	2	2	0	0	0	0	0

A Displacement of major artery
B Irregularities of major artery wall
C Change of calibre in small arteries
D Parenchymatous accumulation of contrast medium
E Increased thickness of the gastric wall

A preshaped polythene catheter (MIKAELSSON 1965) was introduced transfemorally under local anaesthesia and 25 to 30 ml sodium iothalamate (Conray 400) were injected into the coeliac artery at 10 to 12 ml per second. Frontal and oblique films (right or left shoulder elevated) were usually obtained. The superior mesenteric artery was examined with 20 ml of contrast medium and frontal roentgenograms. The length of the series was over 30 seconds at least so as to include the late venous phase, especially in the portal vein. The stomach was distended in 9 patients by means of an effervescent tablet swallowed before the angiography. Unsuccessful attempts were made in 4 additional patients to inject contrast medium into the left gastric artery with a MIKAELSSON catheter furnished with a curved tip 2 cm longer than normal. The angiographies were evaluated according to the criteria in Table 1.

Results

Operation confirmed a gastric tumour in 13 patients, this being revealed in the remaining 2 patients by autopsy and gastroscopy respectively. The tumour was removed in 7 patients (Table 1). The angiographies failed to supply information regarding operability.

The tumour size measured at operation and the pre-operative angiography were compared (Table 2): no growths below 3 cm in diameter were present in

Tabl 2

An, iographic changes in 15 patients with gastric neoplasm related to its si_e

Size of tumour	No of cases	Angiographic f ndings Coeliac art					Superior mesenteric art				
		A	B	C	D	E	A	B	C	D	E
0–3 cm	0										
3–5 cm	3	2	2	2	2	1	1	1	1	1	0
Over 5 cm	6	2	4	5	5	5	0	0	0	0	0
Whole stomach	4	1	1	3	4	0	0	1	2	0	1
No operat on	2	0	0	0	2	2	0	0	0	0	0

One pati nt with benign lesion
A to E see T ble 1

the material The small number of cases in each group prevented any statistical evaluation of the correlation between tumour size and the angiographic findings However the most constant angiographic sign in all sizes was a change in the calibre of small arteries and parenchymatous accumulation of contrast medium The latter sign was also present in one of the patients with a benign tumour The group of gastric tumours more than 5 cm in diameter had more extensive angiographic changes than those of the group of smaller tumours

No correspondence was evident between the macroscopic and angiographic sizes of the tumours

As stated a comparison was made of the angiographic findings and the histologic type of tumour (Table 3) Sarcomatous tumours (reticulosarcomas and leiomyomas) presented few changes compared to carcinomas The different types of carcinoma could not be identified angiographically

The angiographic changes A to E most frequently lay in the coeliac artery while those in the superior mesenteric artery were rare (Tables 1 2 and 3)

No complications were noted apart from a few instances of small and insignif icant haematomas at the femoral puncture

Selective angiography of the left gastric artery It was impossible in 4 p t manoeuver the tip of the catheter freely in the coeliac artery in order t it it into the origin of the left gastric artery No angiographic series w ined The coeliac axis was found at operation to be stenotic due to ma infiltra tion

Table 3

Angiographic changes in 15 patients with gastric neoplasm related to histologic findings

Type of tumour	N of cases	Angiographic findings									
		Coeliac art					Superior mesenteric art				
		A	B	C	D	E	A	B	C	D	E
Adenocarcinoma	6	3	3	5	5	4	0	1	1	0	0
Adeno- and solid carcinoma	3	1	2	1	3	3	0	0	0	0	0
Colloid carcinoma	2	0	1	2	2	0	0	0	1	0	0
Anaplastic carcinoma	1	0	1	1	1	0	1	1	1	1	0
Reticulosarcoma	2	0	0	0	2	1	0	0	0	0	1
Leiomyoma (benign)	1	1	0	1	0	0	0	0	0	0	0

A to E see Table 1

Discussion

It is commonly accepted that angiography is of minor value in the diagnosis of gastric neoplasms (ALLEN et coll. 1971). As the latter pointed out, this procedure adds little to the information gained by barium and endoscopic examinations. A possible indication for angiography could be the evaluation of the extent of a gastric neoplasm establishing a preoperative measure of its operability. The present investigation revealed that neither this nor an estimation of the size was possible even by a detailed assessment of the angiographic changes. The general impression was that the changes in fact tended to underestimate the tumour size revealed at operation. The change of calibre in small arteries was evident only in a limited area of even a large tumour.

The changes were almost exclusively in the coeliac artery and its branches, while those in the superior mesenteric artery were insignificant. This is in keeping with the statement by BOIJSEN et coll. that the arterial supply for the stomach is largely derived from the coeliac artery.

Angiography in the diagnosis of small gastric tumours has been advocated by SUNDGREN. As no cases of early gastric carcinoma were present in the present work no opportunity arose for the method to be evaluated under these particular circumstances. Selective angiography of the left gastric artery could not be performed with the large masses as the process had propagated to the coeliac axis to make catheterization impossible.

Carcinomas ranging from scirrhus to anaplastic tumours produced all types of angiographic abnormalities however without any correlation between vascular

changes and histology Both a reticulosarcoma and a leiomyoma were accompanied by discrete angiographic alterations

The present investigation has indicated that angiography of the large arteries supplying the stomach in confirmed gastric malignancy adds no further information to the estimation of size and operability even with a detailed evaluation of the vascular changes

SUMMARY

Pre-operative coeliac and superior mesenteric angiographies were carried out in 15 cases of histologically verified gastric tumours No correspondence was evident between the macroscopic and angiographic sizes of a tumour neither could the resectability be estimated by angiography No correlation between the angiographic appearance and the histology type of neoplasm was apparent

ZUSAMMENFASSUNG

Präoperative Angiographie der coeliacalen und der oberen Mesenterialarterien wurde bei 15 histologisch nachgewiesenen Fällen eines Magentumors vorgenommen Es fand sich keine Übereinstimmung zwischen der makroskopischen und der angiographischen Tumorgrösse auch die Resezierbarkeit konnte nicht durch die Angiographie bestimmt werden Es fand sich keine Korrelation zwischen dem angiographischen Bild und dem histologischen Typus des Neoplasmas

RÉSUMÉ

Les auteurs ont fait des angiographies coeliaques et mesentériques supérieures préopératoires dans 15 cas de tumeur de l estomac vérifiée histologiquement Ils n ont pas trouvé de correspondance évidente entre les dimensions macroscopiques et angiographiques d une tumeur L angiographie n a pas permis non plus d apprécier l opérabilité Il n y avait pas de corrélation apparente entre l aspect angiographique et le type histologique de la néoplasie.

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AORTA, HEART AND LUNG VESSELS IN IDIOPATHIC PULMONARY EMPHYSEMA RELATED TO PULMONARY FUNCTION

BJORN NORDENSTROM and TATSUO KUMAZAKI

This investigation was prompted by the observation that the heart appears unusually small and the aorta abnormally wide in a certain type of pulmonary emphysema often called *diffuse* or *idiopathic emphysema* It was felt that these cardiovascular changes and the actual type of emphysema may be considered as manifestations of a common pathogenetic factor The complexity makes a brief survey of certain relevant facts and limiting factors necessary for an understanding of the methods applied and the discussion of the results

Emphysema is classified (but slightly modified) according to REID in Fig 1 The idiopathic type of emphysema may be divided into centrilobular and panlobular in which the retractive forces of the lungs are decreased due to the loss of parenchyma (CHRISTIE 1934 STEAD et coll 1952 McLEAN 1956 1958 PIERCE & EBERT 1958 PIERCE et coll 1959 1961 HEARD 1960 MENEELY et coll 1962 GIESE & HARTUNG 1964 REID 1964 FITZPATRICK 1967)

CUDKOWICZ & ARMSTRONG (1953) reported obliteration of the intrapulmonary bronchial arteries in diffuse atrophic emphysema The central pulmonary arteries and bronchi however were well supplied with systemic arterial blood

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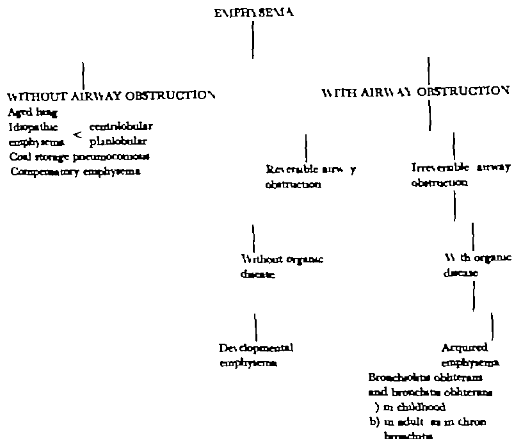


Fig 1 Classification of emphysema (partly after Reid 1964)

from large precapillary anastomoses communicating with the vasa vasorum of the pulmonary arteries (which are derived from the bronchial arteries)

Centrilobular emphysema (LEOPOLD & GOUGH 1957 LEOPOLD & SEAL 1961 WYATT et coll 1964 a b THURLBECK 1967) is characterized by a central loss of tissue with the periphery of the secondary lobules well preserved The abnormalities are predominately developed in the apical anterior and posterior segments of the upper lobes and apical segments of the lower lobes and in the early stages mostly in the subpleural parts of the lungs

Panlobular emphysema or as it is sometimes termed panacinar emphysema (WYATT et coll 1962 1964 a b THURLBECK 1967) is characterized by a uniform distribution of air sacs throughout the secondary lobules of the whole lung



Fig 2 Idiopathic emphysema with a small heart and a large aorta The three dimensions for the measurements of heart volume are indicated

The heart has been much investigated in pulmonary emphysema it has often been stated that the right ventricle is enlarged when the condition is advanced (WYATT et coll 1964 b) the examinations were largely performed post mortem It would appear however that the right ventricle as well as the whole heart is in the living, seldom enlarged in advanced cases of uncomplicated emphysema MOUNSEY (1954) CROMIE (1961) HICKEN et coll (1966) CULLEN et coll (1970) OUTHRED et coll (1970) EDWARDS et coll (1971) have also stressed that no association between right ventricular hypertrophy and the grades of emphysema was present in their post mortem material FORAKER et coll (1970) reported that autopsies had indicated that the left ventricular myocardial coronal area was strikingly diminished in severe emphysema both absolutely and relatively to total ventricular myocardium The left ventricular cavity was also smaller in advanced emphysema this premise was supported by FISHMAN (1971)

A comparison between heart volume determinations by radiology in emphysema and non-emphysema patients appears not to have been made Most publications on cardiac size in emphysema of the living are unfortunately based only on measurements of the frontal projection of the heart in chest films and are therefore inconclusive

The observation that patients with extensive generalized emphysema have an abnormally small heart and a large aortic arch diameter (large cross sectional area of the aortic arch) is illustrated in Fig 2 A small heart may well be explained by low circulatory volume in advanced emphysema This and the absence of increased systemic blood pressure makes it on the other hand difficult to explain a wide aorta It has also been observed that the left ventricle is usually small in size although it appears hypertrophic while the right ventricle in vivo in uncomplicated idiopathic emphysema is of normal size and shape The



Fig 3 Idiopathic emphysema of the panlobular type) p b) anterior part and) posterior part of right lung with fine pulmonary vessels in the whole lung some of the peripheral essels are absent or displaced due to emphysema

dominating appearance of the p a lung structures are fine peripheral pulmonary vessels which due to the depth of the chest, overlap and give the impression of uniform distribution (Fig 3 a) The more representative oblique views indicate deviations of fine lung vessels or the absence of vessels known to be cau ed by emphysema blebs (Fig 3 b c) These abnormalities are present uniformly in both lungs and correspond to panlobular emphysema

A right lung with peripheral vascular changes of the type present in centri lobular emphysema appears in Fig 4 with more advanced vascular change the upper than in the lower part of the same lung

A clear distinction between the centrilobular and panlobular emphysem is often difficult to make The two will be dealt with as one unit as bot are ub divisions of the idiopathic type of emphysema

The width of the thoracic aorta should normally correspond to the an ount o blood pumped by the heart A close relationship also exists betw en th e cardiac size and the flow under normal circulatory conditions The flo in id opathic

b

Fig 4 a) Idiopathic emphysema of the centrilobular type in mostly the pper lateral part of the right lung Considerable narrowing and displacement of the peripheral vessels b) The ascular bnormalities are less pparent in the lower part of the lung

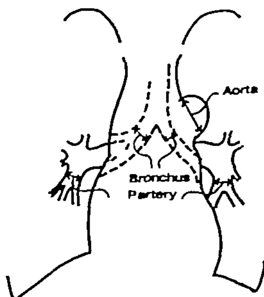


Fig 5 The diameters of the right and left bronchi were measured about 2 cm distal to the carina The diameters of the pulmonary arteries of the right and left lower lobes were measured in p.a. or oblique films abov the origin of the pical segmental artery

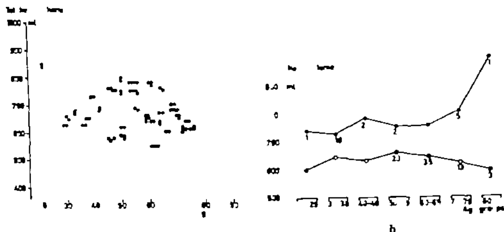


Fig 6) Total heart olume in males of different ages nd b) mean heart olume Th heart is smaller in patients with diffuse emphysema (O) than in controls (●)

pulmonary emphysema is known to be small and the systemic pressure low or normal Enlargement of the aorta in relation to heart size should therefore depend upon a quality change in the aortic wall with resulting increase in its diameter

It was also thought that the abnormalities due to emphysema of the idiopathic type and the anticipated widening of the aorta might reflect a degenerative disease secondary to a common factor The possible role of the bronchial arteries in the lung parenchyma and the vasa vasorum in the aortic wall will be treated in the general discussion The small heart may well be secondary to diminished pulmonary function Of certain interest in this connection are the observations that human working capacity is closely related to cardiac size (HOLMGREN & OVENFORS 1960 HOLMGREN et coll 1960 EKLUND et coll. 1967)

Material and Methods A total of 100 men and 50 women without clinical or unequivocal radiologic signs of emphysema were used as normal material for comparison They were selected in age groups and number with anthropometric data (length and weight) as closely comparable as possible to those with emphysema

As no physiologic function tests were available in the control materia 1 function values were calculated indirectly by the methods of BERGLUN et o l (1963) BIRATH et coll (1963) and GRIMBY & SODERHOLM (1963)

The patients considered to have emphysema had been referred ith this diagnosis or had clinical and radiologic signs of the disease Complete data were available on the physiologic lung function tests In all 99 men and 44 women

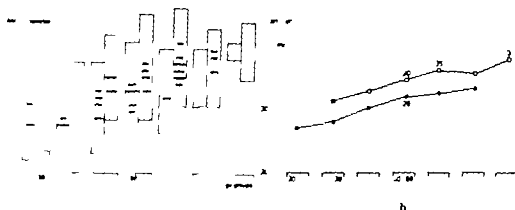


Fig 7) Aortic rch diameter in males of different ge groups and b) mean aort rch diameter The aorta is larger in the emphysema patients (O) than in the controls (●)

with the idiopathic type of pulmonary emphysema were examined radiologically Those with localized bullous emphysema other types of emphysema, diffuse lung conditions or signs of heart disease were excluded

The roentgen examinations of the lungs were made in full inspiration at 180 kV in at least one series of p a lateral, 45 left and right anterior oblique positions and with one low kV (100 kV) p a film

The heart volume was determined by the method described by LYSHOLM et coll (1934) JONSELL (1939) LILJESTRAND et coll (1939) with measurement of the long axes of the heart in the p a and the depth of the heart in the lateral view (Fig 2) A standard correction factor of 0 42 was always used The value of the total heart volume was obtained only in the erect position since the correlation had to be made in relation to the diameters of the aorta

The external aortic arch diameter was measured in the p a view in mm (Fig 5) (See also EFTAT et coll 1965) A barium swallow was sometimes employed to outline the medial border of the aorta The measurements naturally often required variations in the exposure factors

The diameters of the lower lobe pulmonary arteries were measured immediately below the origin of the apical segmental artery of the lower lobe on each side (Fig 5)

The diameters of the left and right main bronchi were measured immediately above the origin of the upper lobe bronchi (Fig 5)

A correlation factor (the cardio-aortic index) was calculated by dividing the heart volume with the aortic arch diameter

The individual measurements in the material as well as the cardio-aortic indices were compared

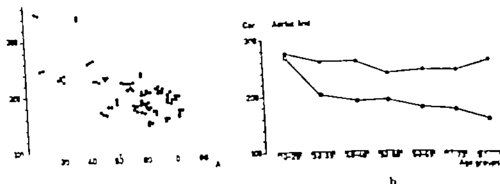


Fig 8 a) Total heart volume in ml divided by aortic arch diameter produces a relative heart volume termed the cardio-aortic index This is lower in males with emphysema than in controls b) Mean cardio-aortic index in all males This decreases with age and is lower in males with emphysema (O) than in controls (●)

The cardio-aortic indices were compared with the results of pulmonary function tests of inspiratory reserve volume residual volume, forced expiratory volume as a percentage of total lung capacity maximum voluntary ventilation in 40 seconds residual volume to total lung capacity and functional residual volume All these were obtained from the routine clinical records

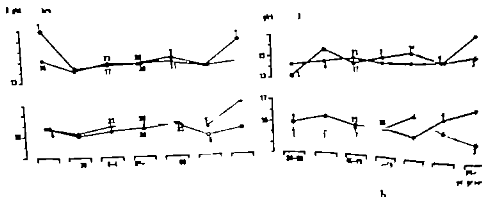


Fig 9 a) Mean diameter of right and l[illegible] main bronchi No obvious diff[illegible] different age groups or between contr[illegible] [illegible]rd males with emphysema b) M[illegible] the arteries of the right and left l[illegible] [illegible]bes in males of different [illegible] differences evident between these grou[illegible] or between the males with emphysema (O) and controls (●)

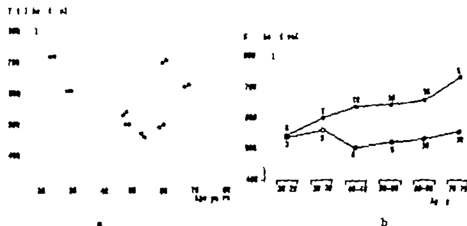


Fig 10 a) Total heart olume in the women with emphysema b) Mean heart volume in omen the heart is smaller in those with diffuse emphysema (○) than in the controls (●)

Results

The total heart volumes of all the men have been plotted against age (Fig 6 a) The cases of emphysema have been grouped in the right lower part of the figure

The same material was arranged in age groups against the mean heart volumes in Fig 6 b the difference between the controls and the emphysema cases became even more obvious The number of patients in certain age groups was small but the whole material presented a 15 to 20 per cent smaller total heart volume in the emphysema cases compared with that in the controls

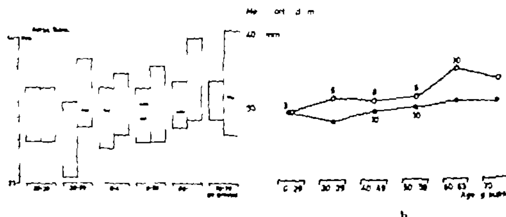


Fig 11 a) Aortic arch diameter in the women b) Mean aortic arch of greater diameter in the women with emphysema (○) than in the controls (●)

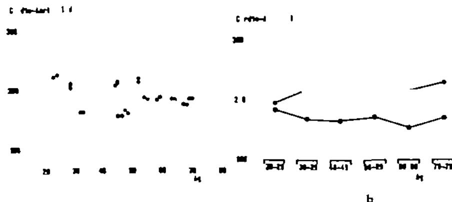


Fig 12 a) Total heart volume (ml) divided by aortic arch diameter (cm) produces the cardio-aortic index lower in women with emphysema than in the controls b) The mean cardio aortic index is lower in women with emphysema (O) than in controls (●)

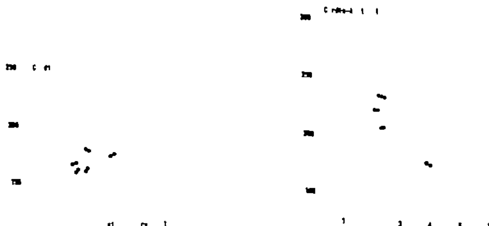


Fig 13

Fig 14

Fig 13 Twenty seven males with diffuse emphysema of the lung Relatively good direct correlation exists between the cardio-aortic index and the inspiratory reserve volume

Fig 14 Differentiation between 25 males with emphysema (O) and the same number of controls (●) more easily obtained by the cardio-aortic index than by the corresponding values for the residual volumes (l)



Fig 15

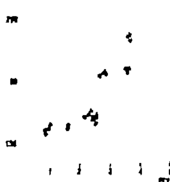


Fig 16

Fig 15 Good differentiation obtained between males with emphysema (O) and controls (●) by means of the cardio-aortic index and the corresponding values for vital capacity (l)

Fig 16 Relatively good linear relationship between the cardio-aortic index and forced expiratory volume (l) during one second in 66 patients The patients with emphysema (O males Δ females) are distinctly separated from the controls (● males ▲ females)

The diameters of the aortic arch as measured in mm in p a films are collected in age groups in Fig 7 a The emphysema patients had a larger diameter than the controls which was more apparent when the mean diameter of the aorta was calculated (Fig 7 b) The diameter was increased with age in both the emphysema patients and the controls

A cardio-aortic index was calculated by dividing the heart volume by the aortic diameter expressed in cm for each patient so as to obtain a comparable correlation factor the ratios obtained were plotted against the ages (Fig 8 a) Most of the cardio-aortic indices of the emphysema patients appear in the lower half of the chart the corresponding mean values are presented in Fig 8 b A tendency for a lowering of the index with increasing age existed for both these and the controls

A comparison was made between the mean diameters of the left and right main bronchi in all the patients (Fig 9 a) This produced the surprising result that no differences in calibre existed between the controls and the emphysema patients in the different age groups Measurements of the mean diameters of the right and left lower lobe arteries suggested enlargement of the pulmonary artery on both sides, although in certain age groups this was not always apparent (Fig 9 b)



Fig 17



Fig 18

Fig 17 Integrated use of the cardio-aortic index and forced expiratory volume (1) as percentage of total lung volume separates the patients with emphysema (○ males △ females) and the controls (● males ▲ females)

Fig 18 Relatively good linear relationship between the index and the values for maximum voluntary ventilation during 40 seconds (○ males △ females with emphysema ● male ▲ female controls)

An investigation was also made of 44 women with emphysema and a control group of 50 women considered clinically and radiologically to have normal lungs The heart volumes were plotted against age (Fig 10 a) As with the men, most of the emphysema patients were in the lower part of the chart The mean heart volumes and number of subjects in the different age groups appear in Fig 10 b Again as with the males the heart volume was lower in the females with emphysema

The diameters of the aorta were plotted for the different age groups of both sexes (Fig 11 a) The mean values indicated that the diameter of the aorta was larger in the emphysema patients than in the controls (Fig 11 b)

The cardio-aortic index for the women was plotted against age (Fig 12 a) the emphysema material lies in the lower part of the chart The mean values of the index plotted against age groups (Fig 12 b) produced correlation between the emphysema women and the controls similar to that in the men The indices for the male controls were approximately 250 and for the females 220 while those for emphysema had fallen to about 180 in the men and 160 in the women

The correlations have all been based on pure radiologic observations and measurements As an independent morphologic control of the lung changes was lacking comparison was supplied by some of the routine physiologic function

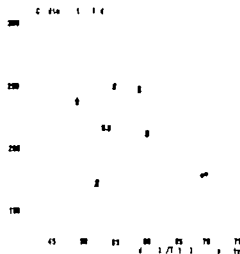


Fig 19

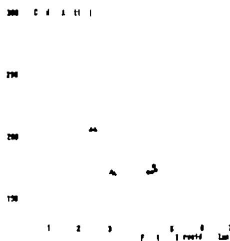


Fig 20

Fig 19 Correlation between the index and residual volume (l) to total lung capacity in 68 patients (O males Δ females with emphysema ● male ▲ female controls)

Fig 20 Correlation between the cardio-aortic index and functional residual volume (l) in 64 patients The values for the functional residual volumes only just separate the patients with emphysema (O males Δ females) from the controls (● males ▲ females)

tests generally applied for a quantitative evaluation of pulmonary emphysema

None of the function tests present in the records was excluded in the comparisons Reports on different tests were however sometimes absent and may have explained the varying number of patients in the different comparisons

The cardio-aortic index considered in relation to the inspiratory reserve volume in 27 of the emphysema males examined by the physiologic function tests produced relatively good direct correlation (Fig 13) A low index corresponds to low inspiratory reserve volume which in turn occurs in emphysema The index plotted against the residual volumes produced clear differentiation of the two groups of patients (Fig 14) On the other hand residual volume determinations separated only some of the controls from the emphysema patients

The relationship between cardio-aortic index and vital capacity also presented a certain degree of direct correlation (Fig 15) The correlation between the index and forced expiratory volume per second ($FEV_{1.0}$) was demonstrated in a combined material of men and women (Fig 16) The correlation between the index and the percentage of forced expiratory volume to total lung volume disclosed better separation of the emphysema patients from the controls (Fig 17) given by the physiologic function test or the index alone The index compared to the maximum voluntary ventilation in 40 seconds (MVV_{40})

revealed remarkably good correlation (Fig 18) The index was considered in relation to the residual volumes to total lung capacity in Fig 19 It is believed that this ratio is one of the best function tests for the evaluation of the degree of emphysema (SWENY et coll 1960) The figures for this ratio in emphysema are situated to the lower right of the chart and those of the controls to the left The separation of the latter from the emphysema patients is, however even better obtained by the index than by the function test

The index was also compared with the functional residual lung volume (Fig 20) The figure revealed good separation of the control from the emphysema material The functional residual volume parameter on the other hand, failed to disclose any obvious difference between the two groups

Discussion

The diminished heart volume in idiopathic pulmonary emphysema may be secondary to low physical working capacity A reduction in the retractive forces of the lung tissue will also produce a diminished inflow gradient for the blood into the thorax and decrease the respiratory effect on the diastolic filling of the heart The lowered capacity for gas exchange may al o be an important factor in the relatively low physical activity of these patients Alterations in the cardiac volume of emphysema may consequently bear some correlation to its degree as the normal volume varies considerably it must be correlated to an appropriate parameter in each individual

The diameter of the aortic arch was chosen as a correlative parameter for the heart volume The main efferent tube of any pump should normally be of a dimension to carry the full output The diameter of the aorta probably matches the pumping capacity of the heart in normal biologic conditions A certain ratio should therefore exist between the volume of the normal heart and the size of the aorta this is supposed to vary to some extent in different age groups due to normal quality changes in the pump-tube system due to aging An absolute increase in diameter of the aorta occurred in the emphysema patients in all age groups A large aorta is not compatible with normal systemic blood pressure and reduced heart volume in the emphysema patients A change in the quality of the aortic wall is therefore likely to be present and gives rise to the question whether the alterations in quality in the pulmonary parenchyma and those anticipated in the aorta have a common denominator

It is of interest that the central bronchi and the central pulmonary arteries have presented no evidence of enlargement in the emphysema patients compared with the controls It is possible that some local degenerative changes may have been present in the lungs and the wall of the aorta in this material of idiopathic

emphysema The absence of changes in calibre of the central pulmonary arteries may also have been against more general vascular involvement A related factor for degeneration in the pulmonary parenchyma and the aortic wall that spares the central pulmonary arteries and bronchi, may be the function of the nutrient vessels of the affected organs, that is the bronchial arteries and the vasa vasorum of the aorta Such a degenerative process due to insufficient bronchial arterial supply with preserved nutrition of the central bronchi and pulmonary arteries accords with the work of ISAAKSOHN (1871) LOPSCHKE (1928) CUDKOWICZ & ARMSTRONG (1953) DELARNE (1946) and FLORANGE (1960)

The bronchial arteries and the vasa vasorum of the aorta are all nutrient vessels of common origin No investigation appears however so far to have been made about possible insufficiency of the vasa vasorum in idiopathic emphysema Degeneration or atrophy due to insufficient systemic blood supply to the aortic wall and the pulmonary parenchyma seems, however to be a possible preliminary explanation for the alterations in these structures

The absence of enlargement of the heart and the central pulmonary vessels in uncomplicated idiopathic emphysema seems to indicate that cor pulmonale and enlargement of the central pulmonary vessels are rarely present in vivo even in relatively advanced uncomplicated emphysema

The cardio aortic index and physiologic lung function tests have presented remarkably good correlation This has been especially true between the index and the inspiratory reserve volume, the maximum voluntary ventilation the forced expiratory volume per second and the forced expiratory volume as a percentage of the total lung capacity An even better separation of the controls from the emphysema patients was obtained by the index in comparing residual volume vital capacity residual volume/total lung capacity and functional residual volume

Where a qualitative diagnosis of diffuse uncomplicated emphysema can be made it seems possible to use the index as a guide for the quantitative estimation of the functional significance of the lung changes The cardio-aortic index in complications such as cor pulmonale, general myocardial failure and pulmonary hypertension should however tend to move against the normal values due to enlargement of the heart

Conclusions

A qualitative diagnosis of the idiopathic diffuse types of emphysema (centrilobular and panlobular) may usually be made by suitable radiologic examinations with films of high resolution The heart in idiopathic emphysema

is usually small and the aorta wide the heart volume was calculated in 150 controls of different age groups and in 143 patients with emphysema The diameter of the aortic arch as well as the left and right lower lobe bronchi and pulmonary artery were also measured The heart volume was considerably smaller and the aortic diameter larger in patients with uncomplicated emphysema compared with the controls The diameters of the central bronchi and pulmonary arteries were the same in the whole material Evidence has earlier been presented that emphysema may be related to an insufficient bronchial arterial supply to the lung periphery but with the systemic arterial supply to the central bronchi and vessels preserved The reason for the widening of the aorta is still obscure but may depend on a similar change in the nutrient vasa vasorum of the aortic wall these are from the same source as the bronchial arteries The decrease in heart volume may variously be correlated to the functional effect of the emphysema changes and has been discussed in detail

The cardio-aortic index (heart volume/aortic diameter) enabled correlation to be made against different physiologic function tests Remarkably good agreement was evident with the inspiratory reserve volume the maximum voluntary ventilation and the forced expiratory volume An even better separation of the controls from the emphysema patients was obtained by the index compared with the residual volume vital capacity residual volume/total lung capacity and functional residual volume The index may perhaps become a practical guide in the quantitative estimation of the functional significance of the pulmonary abnormalities in uncomplicated diffuse emphysema

SUMMARY

The size of the heart and of the aorta has been investigated in 143 patients with idiopathic emphysema. The cardio-aortic index is described and its val in the estimation of the correlation with the arious tests f physiologic function discussed

ZUSAMMENFASSUNG

Die Grosse des Herzens und der Aorta wurde bei 143 Patienten mit idiopathischem Emphysem untersucht Der Herz Aorten Index wird beschrieben und dessen Wert bei der Bestimmung der Korrelation zu verschiedenen Tests der physiologischen Funktion diskutiert

RÉSUMÉ

Les dimensions du cœur et de l aort ont et etudiees chez 143 malades tteints d emphysème idiopathique Les auteurs decrivent l index cardio-aortique et examinent son interet dans l estimation de la correlation avec les divers tests de la fonction physiologiqu

emphysema The absence of changes in calibre of the central pulmonary arteries may also have been against more general vascular involvement A related factor for degeneration in the pulmonary parenchyma and the aortic wall that spares the central pulmonary arteries and bronchi may be the function of the nutrient vessels of the affected organs, that is the bronchial arteries and the vasa vasorum of the aorta Such a degenerative process due to insufficient bronchial arterial supply with preserved nutrition of the central bronchi and pulmonary arteries accords with the work of ISAAKSOHN (1871) LOESCHKE (1928) CUDKOWICZ & ARMSTRONG (1953) DELARNE (1946) and FLORANGE (1960)

The bronchial arteries and the vasa vasorum of the aorta are all nutrient vessels of common origin No investigation appears however so far to have been made about possible insufficiency of the vasa vasorum in idiopathic emphysema Degeneration or atrophy due to insufficient systemic blood supply to the aortic wall and the pulmonary parenchyma seems however to be a possible preliminary explanation for the alterations in these structures

The absence of enlargement of the heart and the central pulmonary vessels in uncomplicated idiopathic emphysema seems to indicate that cor pulmonale and enlargement of the central pulmonary vessels are rarely present in vivo even in relatively advanced uncomplicated emphysema

The cardio-aortic index and physiologic lung function tests have presented remarkably good correlation This has been especially true between the index and the inspiratory reserve volume, the maximum voluntary ventilation, the forced expiratory volume per second and the forced expiratory volume as a percentage of the total lung capacity An even better separation of the controls from the emphysema patients was obtained by the index in comparing residual volume vital capacity residual volume/total lung capacity and functional residual volume

Where a qualitative diagnosis of diffuse uncomplicated emphysema can be made it seems possible to use the index as a guide for the quantitative estimation of the functional significance of the lung changes The cardio-aortic index in complications such as cor pulmonale, general myocardial failure and pulmonary hypertension, should however tend to move against the normal values due to enlargement of the heart

Conclusions

A qualitative diagnosis of the idiopathic diffuse types of emphysema (centrilobular and panlobular) may usually be made by suitable radiologic examinations with films of high resolution The heart in idiopathic emphysema

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FROM THE DIVISION OF PHARMACOLOGY (DIRECTOR PROF P LINDGREN) DEPARTMENT OF DRUGS NATIONAL BOARD OF HEALTH AND WELFARE 104 01 STOCKHOLM AND THE DEPARTMENTS OF DIAGNOSTIC RADIOLOGY (DIRECTOR PROF G F SALTZMAN) AND SURGERY (DIRECTOR PROF S BORGSTRÖM) UMEA UNIVERSITY 901 85 UMEA SWEDEN

INTRAVENOUS CHOLEGRAPHY AND PERORAL CONTRACEPTIVES

A preliminary report

P LINDGREN G F SALTZMAN and E ZEUCHNER

The clinical trials with parenterally administered contrast media that have been in progress for some years at the department of diagnostic radiology at the teaching hospital in Umea have necessitated the routine recording of all side effects During the same period the surgical department has been investigating the side effects resulting from oral contraceptives (PIHL et coll 1968) A considerable number of side effects have been observed when Biligrafin was used as contrast medium for cholegraphy in young women taking contraceptives suggesting that there might be a relation between these compounds These observations prompted us to analyse th[illegible] age and sex distribution in a series of 500 consecutive intravenous cholegraphies and to carry out circulation examinations in animals to gain further information

Communicated [illegible] the 28th C[illegible] Scandinavian Radiological Society in Umea Sweden 14—17 June 1967 Sub[illegible] publication 2 April 1973

Table

Clinical and radiologic findings (For details concerning the examination of the biopsy material with light and electron microscopes see Pihl *et coll 1968)*

Case	Bilirubin mg	Thymol	Alkaline phosphatase	GOT	GPT	LDH	HBD	Sulfobromophthalein	Liver biopsy	Cholegraphy	
										Contrast fill ng of bile ducts	Sid effects
1	0 8	0 4	11 2	87	54	340	285	–	Pathol	+	+
2	0 9	0 2	8 3	98	160	245	170	–	Pathol	0	–
3	0 8	–	9 4	110	130	250	170	5 3	Pathol	0	+
4	1 3	2 3	11 0	49	52	380	240	–	Pathol	0	–
	0 4	0 6	–	28	32	215	140	5 0	Pathol	+	–
6	0 4	–	–	48	66	100	250	4 1	Possibly pathol	+	–
7	0 6	1 0	4 9	18	16	–	–	6 2	Not done	+	–
8	0 3	1 7	7 7	26	23	150	140	–	Not done	0	
9	0	–	–	22	23	180	150	–	Not done	+	–
10	1 1	0	2 7	30	31	260	230	12 9	Not done	+	
11	0 6	0 4	3 3	–	–	–	–	–	Not done	+	–

Material Intravenous cholegraphy was performed in 11 women who had been taking Anovlar (Schering) Conluten (Astra) or Lyndiol mite (Pharmacia) for a long period The dominant substance in all these contraceptives is a progesterone derivative with small amounts of oestrogen added The cholegraphy was carried out because of uncharacteristic abdominal pain the contrast medium used being ioglycamide (Biliviistan) which gives less side reactions than other available contrast media (Briemar et coll 1971 and others) The serum bilirubin concentration was recorded for all the women, and in most of them a thymol turbidity test as well as tests for alkaline phosphatase and transaminase (GOT GPT LDH and HBD) were also performed Sulfobromophthalein loading was carried out in 5 instances In 6 women, liver biopsy was done, the material obtained being examined in both light and electron microscopes

In view of the observations in these 11 cases the side effects in a series of 500 consecutive intravenous cholegraphies were analysed with respect to the age and sex distribution This material has been described by Briemar et coll in another context but hormonal aspects were not taken into consideration in their report

Since progesterone is the dominant component in all contraceptives, we pretreated a few cats with large doses of progesterone intramuscularly (Progestin

Pharmacia) and the following day administered Bilivistan intravenously and Biligrafin forte in an amount corresponding to a large clinical dose The systemic blood pressure was measured in the left common carotid artery and the pressure in the right ventricle through a fine plastic catheter introduced into the heart via the right jugular vein The recordings were made with electromanometers (Statham P 23AA) connected to a Grass model 5 polygraph, as described in more detail in a previous paper (LINDGREN et coll 1964)

Results

Clinical investigation The findings in the 11 cases are given in the Table

Two remarkable observations were made in connection with the cholegraphies in these patients First, there were 4 cases in which despite normal serum bilirubin concentrations no contrast filling of the bile ducts was obtained Although the present material is small, this frequency is undoubtedly surprising, considering that BRISMAR et coll among 500 cholegraphies, had only 4 unexplainable cases of defective bile duct filling in conjunction with normal bilirubin values Secondly there was a high incidence of side effects Five patients had nausea and vomiting, in other words the most troublesome and unpleasant reactions (apart from a case of circulatory collapse reported by BRISMAR et coll) noted by us in connection with the use of Bilivistan as a contrast medium none of these patients had had similar symptoms before the roentgen examination Compared with the incidence of established side effects from Bilivistan (9 8 per cent) reported by BRISMAR et coll the present frequency seems to be high

There would seem to be some correlation between demonstrable liver injury on the one hand and frequency of side reactions and incomplete filling of the bile ducts on the other That histologically demonstrable liver injury and defective duct filling would be parallel phenomena is hardly surprising but the high frequency of side effects is noteworthy on the other hand seeing that it has never been possible, in icterus to record definite side reactions due to the contrast medium (THEANDER 1955 BRISMAR et coll)

The progesterone content in the blood is highest in women of fertile age but it varies considerably from phase to phase in the menstrual cycle It has not previously been possible to survey side effect rate in relation to menstrual cycle phase the age and sex distribution in a series of 500 consecutive cholegraphies reveals however that there are noticeable differences with respect to the side effect rate between women of fertile and non fertile ages Like BRISMAR et coll we recorded separately those symptoms which had not been noted before the examination (unmistakable side effect) and such symptoms as had already been present in the same degree before the cholegraphy Of 142 women of fertile age

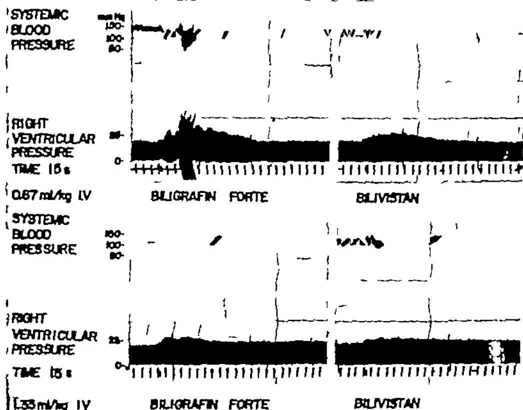


Fig 1 Cat 3 0 kg pretreated (24 h) with progesterone 15 mg/kg intramuscularly Ci ul tory effects of Biligrafin forte (50 %) and Bilivistan (50 %) given as rapid intravenous inj tions

20 (14 1 per cent) had unmistakable side effects and 13 (9 2 per cent) the same symptoms as before examination of 209 women of non fertile age 14 (6 7 per cent) had unmistakable side effects and 18 (8 6 per cent) the same symptoms as before examination

All these clinical observations suggest that there is a relation between female sex hormones and the contrast medium used at intravenous cholegraphy This applies particularly to the incidence of side effects at cholegraphy The material is still small however

Experimental investigation In view of the great preponderance of progesterone in all the oral contraceptives in use at present, a few cats were pre treated as a preliminary step with 15 mg/kg Progestin intramuscularly and 24

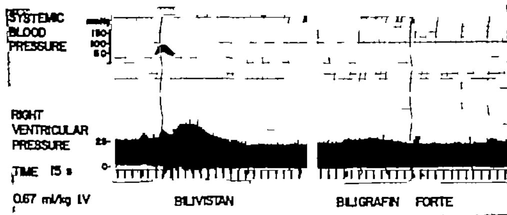


Fig 2 Cat 2 6 kg pretreated (24 h) with progesterone 15 mg/kg intramuscularly Effects on systemic blood pressure and right ventricular pressure of Bilivistan and Biligrafin forte given as rapid intravenous injections

hours later were given a rapid injection of contrast medium, Biligrafin forte or Bilivistan

One characteristic experiment is illustrated in Fig 1 An amount of 0 67 ml/kg Biligrafin forte was administered intravenously and the result was a slightly deeper fall in blood pressure than has generally been observed in untreated animals in earlier experiments (LINDGREN & SALTZMAN 1962) A marked rise in the systolic pressure in the right ventricle occurred at the same time These pressure rises tended to be wave shaped reaching when greatest to approximately twice the initial level After 35 seconds, the cat had a bad vomiting attack which lasted for a further half a minute and could be distinctly observed in the marked oscillations in both blood pressure and ventricular pressure curves The blood pressure and ventricular pressure reactions subsided after a further 3 to 4 minutes A subsequent injection of Bilivistan in the same dose produced a similar reaction though with quantitatively smaller tracings and without the vomiting The two injections were repeated approximately one hour later with the dose doubled The fall in the blood pressure and above all the pressure rise in the right ventricle, were now much less marked suggesting that tachyphylaxis had developed Tachyphylaxis of this type also occurs in cats not treated with progesterone (LINDGREN & SALTZMAN)

The phenomenon makes it difficult to draw conclusions from the experiment with respect to a comparison between the two contrast media It would in fact be reasonable to expect a certain degree of or possibly even a full considerable cross-tachyphylaxis

For this reason, Biliviston was given as the first preparation in the second experiment (Fig 2) The fall in blood pressure was slightly smaller than when Biligrafin was given first, but on the other hand the cat had a relatively low initial blood pressure level The pressure rise in the right ventricle was however of the same order of magnitude as it had been for Biligrafin The rise took place in waves in this experiment also, and subsided after 3 to 4 minutes A subsequent injection of Biligrafin in the same dose produced a relatively small reaction, suggesting that cross tachyphylaxis had developed

Discussion

Although our clinical and experimental series were both small, the observations already made suggest that unfavourable effects may arise in a situation in which ioglycamide (Biliviston) is given to women with high sex hormone activity The consequences in practice, would seem to be a higher rate of side effects in women of fertile age than in women of non fertile age as well as a high rate of side reactions in women who have been on oral contraceptives for a long period and a risk of unsatisfactory contrast filling of the bile ducts in the latter women At the 28th Congress of the Scandinavian Radiological Society where these observations were reported for the first time, WILBRAND in the subsequent discussion, described similar cases with side reactions at cholegraphy in women taking oral contraceptives over long periods In his material also the frequency of the reactions was much higher in women of fertile age than in other patient groups

These clinical observations were complemented by the findings in animal experiments, namely that definitely increased circulatory ioglycamide effects could be observed in cats pretreated with progesterone It should be stressed that the dose of progesterone was very large the object was merely to obtain qualitative information as to whether such a form of pretreatment would in general have any effect on the circulatory side reactions to bile duct contrast media The fall in the blood pressure after an intravenous injection of iodipamide or ioglycamide thus seemed larger than in cats not pretreated with these preparations (BRISMAR et coll) The pressure increase in the right ventricle was remarkable In an earlier paper (LINDGREN et coll) the rise in the systolic right ventricular pressure was given as 10 to 16 per cent over the initial level Biliviston, in similar experiments, has produced slightly smaller reactions (BRISMAR et coll) This level was considerably exceeded in the progesterone treated animals, increases reaching almost 100 per cent being observed for both Biligrafin and Biliviston

As regards the increases in the right ventricular pressure marked tachyphylaxis was observed when only one contrast medium was used, and a considerable degree when iodipamide and ioglycamide were given alternately The

cats displayed a strong tendency to vomit similar to that observed in the women.

The smallness of the material does not permit conclusions to be drawn regarding the mechanism underlying the effects obtained. Increased pressure in the right ventricle has been observed in connection with intravenous administration of several different contrast media and this effect has been placed in relation to increased intravascular erythrocyte aggregation (for references, see LINDGREN et coll.). This tendency to aggregation might conceivably be heightened in connection with peroral contraception. Support for this hypothesis has been contributed by LAURELL et coll. who, after peroral contraception, observed displacements in the relation between the serum proteins that could well have served as a predisposing factor in producing increased intravascular erythrocyte aggregation.

Acknowledgement

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SUMMARY

A preliminary report is given on the side effects observed at intravenous cholegraphy with iodipamid in women who had been taking oral contraceptives over a long period. The age and sex distribution for side effects in a large series of cholegraphies is discussed. The circulatory effects on administration of ioglycamid and iodipamid to cats pretreated with progesterone were also investigated.

ZUSAMMENFASSUNG

Es wird ein vorläufiger Bericht über Nebenwirkungen bei der intravenösen Cholegraphie mit Iodipamide bei Frauen, die lange Zeit orale Antikonzeptionsmittel verwendet hatten, gegeben. Das Alter und die Geschlechtsunterschiede für Nebeneffekt in grossen Serien von Cholegraphien werden diskutiert. Der Zirkulationseffekt nach Gabe von Ioglycamid und Iodipamid bei Katzen, die mit Progesteron vorbehandelt waren, wurde ebenfalls untersucht.

RÉSUMÉ

Les auteurs font une étude préliminaire des effects secondaires observé dans la biligraphie intraveineuse par l'iodipamide chez des femmes qui avaient pris pendant une longue période des contraceptifs par voie orale. Ils examinent sur de grandes séries de biligraphies la distribution des effects secondaires en fonction de l'âge et du sexe. Ils ont aussi étudié les effets circulatoires de l'administration d'ioglycamide et d'iodipamide chez des chats traités préalablement par la progestérone.

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CARCINOMA OF THE GALLBLADDER

A review of 158 cases

H PETTERSSON

Primary carcinoma of the gallbladder is uncommon The early stages are nearly always asymptomatic and if symptoms do occur they are nearly always secondary to co-existing cholecystitis or cholelithiasis More severe symptoms do not appear until the disease is well advanced and has spread beyond the gall bladder these include obstructive jaundice right upper quadrant pain anorexia weight loss and fatigue Palpation in this phase often discloses a mass in the right upper quadrant and occasionally an enlarged liver Some patients fail to seek medical help until they are in an even further advanced stage, with ileus ascites or diffuse gastrointestinal bleeding

An early diagnosis is difficult but necessary if the prognosis is not to be hope less The application of roentgenology in the diagnosis of this disease has until now been limited The results will be described and the value of the radiologic procedures that have been performed in patients with confirmed carcinoma of the gallbladder will be discussed

Material A total of 181 cases of primary malignancy of the gallbladder were collected during the 15 year period 1957 and 1971 This material was previously

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Fig 1 Cholecystography with demonstrable tumour Circumscribed rigid deformity of the wall of fundus of gallbladder Microscopy adenocarcinoma) P b) Obliqu

b

Depending on the questions they underwent cholecystography intravenous cholegraphy percutaneous transhepatic cholangiography survey films of the abdomen contrast examinations of the gastrointestinal tract and angiography (3 cases)

The clinical appearances led to laparotomy in 116 cases, after which the diagnosis could be verified microscopically in the other cases the diagnosis was not established before autopsy

The material was divided into three groups depending on when the radiologic examination was performed in relation to the verification those in which the examinations were accomplished less than six months before the microscopic diagnosis, those in which the interval was between 6 and 12 months and those in which more than 12 months elapsed

Results

Inadequate or no concentration of contrast medium in the gallbladder was the usual finding at cholecystography (Table 1) and in no case was the gallbladder normal Adequate concentration was evident in two cases with a filling defect that at operation appeared to be caused by carcinoma (Figs 1 2) Four cases of so-called porcelain gallbladder (calcification of the gallbladder wall) were noted (Fig 3)

Operative cholangiography was performed in 26 cases, 7 of which had



Fig 2



Fig 3

Fig 2 Cholecystography with demonstrable tumour A segment of the neck of the gallbladder was deformed (→) Operation 5 months later the region was thickened secondary adenocarcinoma

Fig 3 Porcelain gallbladder with malignant infiltration Cholecystography revealed non functioning gallbladder Histology calcification of the wall of the gallbladder which was totally overgrown by a low differentiated adenocarcinoma

narrowing of the common bile duct by a tumour and in one case narrowing of the cystic duct Obliteration of a hepatic duct was observed in another case this at autopsy was seen to be caused by a hepatic metastasis It never appeared that the changes were caused by a tumour arising in the gallbladder

Postoperative cholangiography was performed in 16 cases Malignant obliteration of the hepatic and common ducts was evident in 6 cases all but one observed earlier at the operative examination Infiltration of the cystic duct was present in one case (Fig 4)

Percutaneous transhepatic cholangiography was performed in 2 cases in both of these marked changes were observed with obliteration of the hepatic ducts although it was not possible to localize the primary lesion

Cholegraphy including tomography performed in 8 cases failed to reveal a carcinoma of the gallbladder



Fig 4 Adenocarcinoma of gallbladder removed by cholecystectomy and partial resection of the liver The proximal part of the cystic duct was inoperable Postoperative cholangiography disclosed that the contrast medium was leaking through an infiltrated cystic duct (→)

Survey films of the abdomen disclosed a mass in the right upper quadrant in 3 cases (Table 2) No specific evidence existed that the tumour arose from the gallbladder but on the other hand the appearances were not those simply of an enlarged liver Hepatomegaly was usually caused by metastases from carcinoma of the gallbladder Splenomegaly in one case was based on cirrhosis of the liver in the other the enlargement of the spleen was probably due to pressure from the tumour on the porta hepatis Dilatation of the stomach ileus or ascites some times occurred in advanced cases with extensive carcinomatosis of the peritoneum

The upper gastrointestinal examination disclosed extrinsic pressure and invasion cranially of the bulb and superior part of the duodenum as the most common relevant positive finding (Table 3 Fig 5) Extrinsic pressure and infiltration superiorly on the pylorus and antrum were observed in 5 cases and were due to the presence of a mass in the region of the cystic and common bile ducts in 4 others a change in the duodenum could not be differentiated from a tumour in the head of the pancreas the carcinoma of the gallbladder in these cases had spread to the pancreas Malignant invasion in 7 cases led to gastric retention

Table 2

Findings on survey films of the abdomen

	Time between examination and microscopy		
	Under 6 months	6–12 months	Over 12 months
Total number of examinations	60	3	4
Normal	17	3	4
Mass in right upper quadrant	3		
Hepatomegaly	14		
Splenomegaly	2		
Gastric dilatation	4		
Ileus	5		
Ascites	7		
Gallbladder calculi	11		

The other cases of retention (Table 3) had no direct connection with the carcinoma of the gallbladder) One patient had a fistula between the duodenum and tumour of the gallbladder (Fig 6)

Barium examination of the small bowel was performed in 12 cases one had

Table 3

Findings at upper gastrointestinal examination

	Time between examination and microscopy		
	Under 6 months	6–12 months	Over 12 months
Total number of examinations	93	12	30
Normal	4[illegible]	9	37
Extrinsic pressure and invasion of bulb and superior part of duodenum	11	0	0
Extrinsic pressure and invasion of antrum and pylorus	3	0	0
Duodenal infiltration and displacement simulating tumour of head of pancreas	4	0	0
Gastric retention	7	1	3
Fistula between duodenum and tumour	1	0	0
Duodenal ulcer post ulcerative deformity	7	1	
Gastric ulcer or neoplasm	2	1	2
Small changes without relation to carcinoma of the gallbladder	16	1	8



Fig 5



Fig 6

Fig 5 Adenocarcinoma of the gallbladder infiltrating the bulb the superior part of the duodenum and the antrum

Fig 6 Barium meal Fistula between the duodenum and gallbladder with carcinoma

gastric dilatation and 2 cases had ileus another case had constriction of the transverse colon The colon was examined by the double contrast technique in 53 cases 31 of these examinations were performed within half a year of the histologic diagnosis and 5 had infiltration of the superior wall of the transverse colon (Fig 7) No changes relevant to the diagnosis of carcinoma of the gallbladder were evident in the remaining 22 examinations performed over 6 months before the histologic diagnosis

Two cases included here were subjected to celiac angiography shortly before operation and led to the correct preoperative diagnosis the cystic artery was enlarged, its wall infiltrated and had cut-off branches and neovascularization existed (Fig 8) Another case examined more than a year before operation had normal gallbladder arteries

Discussion

Most roentgenologic methods have proved to be insufficient for the diagnosis of early carcinoma of the gallbladder The present investigation has revealed that almost all relevant positive findings were made only within half a year before the histologic diagnosis i e in an advanced phase of the disease

Cholecystography would be of value if it were possible to obtain adequate concentration of the contrast medium However inadequate or no filling with or



Fig 7

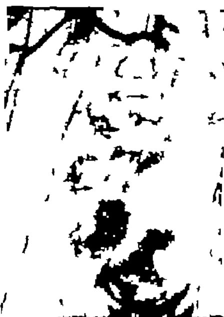


Fig 8

Fig 7 Adenocarcinoma of the gallbladder infiltrating the transverse colon (→) Metastases to th peritoneum has caused constriction of the colon both in the sigmoid and t th h ; tic flexure

Fig 8 Angiography w th simultaneous injection into the celia nd superior mesenteric arteries The cystic artery as ideped and infiltrated (→) Inf ltration nd neov scularity evident long the anterolateral branch of the cystic rtery (→)

without calculi are commonly reported in the literature and is explained by the fact that most malignancies of the gallbladder are combined with cholecystitis or cholelithiasis Reports of adequate concentration with a filling defect due to carcinoma are rare only 6 cases having been described during the last 40 years (BUCKSTEIN 1953 CIMMINO 1958 FELDMAN 1957 SCHINZ et coll 1965 TABAH & MCNEER 1953 TATERKA 1931) The two cases described here illustrate that satisfactory filling of the gallbladder does not exclude malignancy of the wall and that the tumour may in fact be observed

The four cases of porcelain gallbladder demand closer attention Case reports of porcelain gallbladder combined with carcinoma, have been published several times (BROWN 1932 BUCKSTEIN 1953 CORNELL & CLARKE 1959 LANGE 1955 OCHSNER & CARRERA 1963 POLK 1966 ZAWADOWSKI & PLEWNIAK 1936) ETALA (196?) reported 16 cases About 100 cases of porcelain gallbladder have been described among which 22 have been malignant (POLK) During the

5 year period 1967—1971 17 256 cholecystographies performed at our hospital included 8 cases of porcelain gallbladder Only one of these was operated upon and appeared to be benign A total of 48 377 cholecystographies have been performed during the 15 year period of this investigation Thus about 22 cases of porcelain gallbladder should have been encountered with 4 of these malignant The coincidence of porcelain gallbladder and carcinoma of the gallbladder is consequently high The demonstration of a porcelain gallbladder should therefore in itself be an indication for cholecystectomy

It is remarkable that cholecystography was performed more than one year before the pathologic diagnosis in only 36 cases. This may be a good indication as to how difficult it is to interpret the signs of early phases of the disease It is of interest also that of these early investigations not one was normal

It was possible as previously stated to observe the tumour at cholecystography when adequate contrast filling of the gallbladder was obtained Infusion cholegraphy enables the gallbladder to be demonstrated through passive filling Thus, if this examination were always performed when cholecystography failed in giving adequate contrast concentration some further tumours might be revealed This indication for infusion cholegraphy could be one approach to the earlier diagnosis of carcinoma of the gallbladder

Operative and postoperative cholangiography made it possible to demonstrate carcinoma of the gallbladder when spread was present beyond the gallbladder to the ducts owing to the technique of these examinations the early primary tumour was never demonstrated The literature indicates that the diagnosis of carcinoma of the gallbladder has been made at percutaneous transhepatic cholangiography (BAYINDIR 1968 MCNULTY 1967) However with this method more information is gained if it be combined with angiography (BAYINDIR BOIJSEN & REUTER 1967) BOIJSEN & REUTER thus reported a case of obstructive jaundice in which a combination of percutaneous transhepatic cholangiography and celiacography demonstrated carcinoma of the gallbladder with metastases to the hilum of the liver

Survey film of the abdomen failed to afford good guidance as to the diagnosis A local collection of gas in a mass situated at the site of the gallbladder has been regarded as almost pathognomonic by certain writers (ARMINSKI 1949 MCCONNEL 1957) No such case was noted in the present series and the other positive findings were not characteristic.

Upper gastrointestinal examination has been described as the routine method to afford most information regarding the diagnosis of carcinoma of the gallbladder (MCCONNEL 1957 KHILNANI et coll 1962 KVIST KRISTENSEN et coll 1971 KULICZ 1970) This was also the impression in the present investigation. Extrinsic pressure and invasion of the antrum, the pylorus or the bulb or superior

part of the duodenum gave a distinct indication of malignancy in the region of the gallbladder. It was however impossible to determine whether a growth really lay in the wall of the gallbladder. The carcinoma had always extended outside the gallbladder and the cases were beyond effective therapy.

Investigation of the colon with the double contrast technique failed to produce more information than the ordinary colonic enema. The same changes as described here have been reported earlier with the latter technique (LANGE 1955, KVIST KRISTENSEN et coll. 1971).

Among all methods that were evaluated angiography of the abdominal vessels appeared to be the most reliable. This was in accordance with previous investigations, which have indicated celiac or selective hepatic angiography to be a safe means of demonstrating malignancies of the gallbladder (ABRAMS et coll. 1970, BOIJSEN & REUTER 1967, DEUTSCH 1967, REUTER et coll. 1971, ROSCH et coll. 1969, SIRAVEGNA & MESSINGER 1972, WENZ 1967). All published reports have included some of the following criteria of carcinoma of the gallbladder: enlarged hepatic or cystic arteries, infiltration and cut off of the cystic artery or its branches and neovasculature of the cystic wall. ABRAMS et coll. also described irregular thickness of the gallbladder wall, recognizable in the venous phase, which was regarded as an important criterion in the diagnosis of carcinoma of the gallbladder. This was not observed in the present material nor in the 2 further cases examined later in 1972.

Angiography should disclose carcinoma of the gallbladder earlier when the disease is still localized to the wall. However, as in pancreatic carcinoma, the problem is that the patient comes too late for diagnosis owing to the fact that the symptoms in the early phase of the disease are so non-specific. The therapeutic possibilities available today afford only the carcinoma in situ a good prognosis (OHLSSON & ARONSEN 1975). The tumour in the early phase is not demonstrable with any radiologic method.

SUMMARY

A total of 158 patients with carcinoma of the gallbladder were investigated with various radiologic methods during a 15 year period. Almost all relevant positive findings were made in a late phase of the disease when the growth had already spread. A high incidence of porcelain gallbladder and carcinoma of the gallbladder was demonstrated and the presence of a porcelain gallbladder was suggested as indication for cholecystectomy. Upper gastrointestinal examination gave most information among the routine methods but angiography of the celiac and superior mesenteric arteries appeared to produce even more reliable information and should perhaps make a relatively early diagnosis possible.

ZUSAMMENFASSUNG

Insgesamt 158 Patienten mit einem Karzinom der Gallenblase wurden während einer 15 Jahresperiode mit verschiedenen röntgenologischen Methoden untersucht. Fast alle

relevanten positiven Befunde wurden in einer spaten Phase der Erkrankung erhoben wenn sich das Wachstum bereits ausgebreitet hatt Es wird ein haufiges Vorkommen einer Porzellan Gallenblase und einem Krebs der Gallenblase nachgewiesen und das Vorkommen einer Porzellen Gallenblase wird als Indikation fur eine Cholezystektomie angesehen Die obere gastrointestinale Untersuchung ergab unter den Routine Methoden die best Information jedoch scheint die Angiographie der A coeliaca und der A mesenterica superior noch bessere Information zu geben und sollte eine relativ fruhzeitige Diagnose ermoglichen

RÉSUMÉ

Un total de 158 malades atteints d cancer de la vesicule biliaire ont été examines par differentes methodes radiologiques au cours d une periode d 15 ans Presque tous les signes radiologiques positifs on ete constates à une phase tardive de la maladi quand la tumeur etait dejà disseminee I auteur a prouve une haut frequence de vesicul porcelaine et de cancer de la vesicule il pense que la presence d un vesicule porcelaine est une indication de cholecystectomie Parmi les methodes courantes c est l examen gastro intestinal par ose haut qui donne le plus de renseignements mais l angiographie des artères coeliaque et mesenterique superieure parait donner des renseignements encore plus fideles et devrait peut etre permettre un diagnostic relativement precoce

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ARTHROGRAPHY OF THE KNEE WITH A MODIFIED TECHNIQUE

HANS LEVEN

The conventional method of examination of the knee joint consists of stereoscopy in various degrees of rotation after the injection of a contrast medium, any exudate having previously been drained; lateral films with the tibia drawn forwards (drawer sign test) are also taken. The examination is usually carried out on a Lysholm skull table, a Mimer apparatus or the like, as was described by LINDBLOM (1948). Other methods have been published as well, e.g. the so-called double contrast method of Van De Berg which combined with fluoroscopy and slight varus/valgus flexion has been described by ZAKRISSON (1960); no information of how the knee joint could be forced into the drawer sign position was however given.

A modified technique for arthrography of the joint which produces a better representation and easier interpretation than obtainable hitherto is now described.

Fluoroscopy is performed with an over couch tube that can be adjusted by remote control. This enables the beam to be brought parallel to the joint space without altering the position of the leg. The immobilization of the knee joint with a constant static force is performed by slings placed round the leg and attached to the edge of the table with jam cleats (Fig. 1). The advantage compared to earlier methods of immobilization is the ease with which the slings

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Fig. 1. a) The immobilizing arrangement applied to obtain valgus positioning. b) Tibia forward (drawer test). c) Close-up of the fastening of the limb at the edge of the table [illegible]

are locked to the edge of the table for the drawer sign position. A series of a.p. films is obtained with forced varus and another with forced valgus positioning, with inward and outward rotation. The tibia is forced backwards and forwards for the lateral series.

The diagnosis of rupture of the meniscus with fragments interposed between the two condyles is based on, among other things, the presence of an increased amount of contrast medium appearing as a broad band between the condyles. A potential source of error in the diagnosis is that the lower leg may lie in the varus or valgus position. This may displace the two condyles apart and produce a similar increase of contrast medium between them, erroneously indicating the interposition of meniscal fragments. By intentionally applying force tending to produce these positions the possibility of such a diagnostic error may be eliminated. In addition fragments of the menisci may separate better and the meniscal ruptures may thus be recognized more often in a forced valgus or varus position (Fig. 2).

Ruptures of the cruciate ligaments are best seen in lateral projections with the tibia pulled forwards and backwards (Figs 3, 4). The immobilizing arrangement enables steady and powerful forward traction on the tibia to be applied without discomfort to the patient. A positive drawer sign may readily be obtained. Whereas previously the tibia was pulled manually by the examiner who thus remained in the room during the exposure, the present technique enables the staff to leave the patient aside after immobilizing the knee joint.

Primary dodging is effected with the Dodger T apparatus (LOHOLM & JACOBSON 1971, 1972). This has improved the demonstration of the peripheral



Fig 2 Rupture of the medial men cus) Varus position the rupture is not visible b) Valgus position the rupture is demonstrated



Fig 3 Normal findings Drawer test with the tibia pulled a) backwards the anterior cruciate ligament is difficult to apprai b) forwards the anterior cruciate ligament is stretched and now obvious

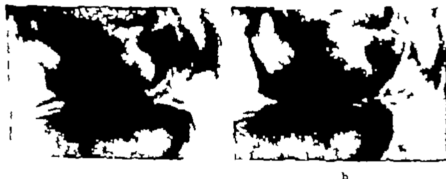


Fig 4 Total rupture of the anterior cruciate ligament) without drawing the tibia forward b) with the tib drawn forwards



Fig 5 Rupture of the medial meniscus and extraarticular leakage of contrast medium The beneficial effect of dodging is evident

parts of the joint and increased the possibility of diagnosing the rupture of collateral ligaments (Fig 5)

The Lindblom method for arthrography of the knee is a most satisfactory one and 95 per cent reliable in the diagnosis of ruptures of the meniscus (LINDVALL 1972) It would appear however that the technique now described can further improve and facilitate the diagnosis of ruptures of the menisci and especially of ruptures of the cruciate ligaments

SUMMARY

A modified technique for arthrography with a positive contrast medium is presented An immobilizing device in addition to fluoroscopy dodging is used to fix and subject the knee joint to different constant static forces during the exposure

ZUSAMMENFASSUNG

Es wird eine modifizierte Technik zur Arthrographie mit einem positiven Kontrastmittel präsentiert Zusätzlich zur Durchleuchtung und den primären rischen Rundbewegungen wird eine Anordnung zur Immobilisierung des Kniegelenks verwendet um dieses zu fixieren und während der Exponierung verschiedenen konstanten statischen Kräften auszusetzen

RÉSUMÉ

Présentation d une technique modifiée d arthrographie avec un moyen de contraste positif L auteur utilise en plus de la radioscopie un dispositif qui immobilise l articulation du genou qui le soumet à différentes forces statiques constantes au cours de l exposition et qui assure une évaluation primaire de l impact de l region du genou

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THE TORTUOUS BASILAR ARTERY

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The basilar artery often forms a regular arch to one side a variation that makes it virtually impossible to diagnose an expanding lesion solely from a lateral displacement of the vessel (LINDGREN 1954 GREITZ & LINDGREN 1961) The course of the basilar artery has therefore become of secondary importance OLSSON (1953) in an evaluation of vertebral angiography in acoustic nerve tumours observed that the vascular pattern varied widely from one case to another The basilar artery however failed to deviate towards the tumour side in 10 and was situated in the midline in 4 of the 14 cases reported

Investigations have been carried out both in the venous and the arterial systems to determine the cause for the tortuous appearances of certain blood vessels (NYLANDER 1969 RICKENBACHER 1964 ZÜLCH 1962 EICHHORN & SCHLICHT 1969)

The tortuosity of the blood vessels is caused mainly by the meandering phenomenon in both systems (LEOPOLD & WOLMAN 1960 LEOPOLD & LANGBEIN 1966) The tortuosity tends to be more marked in the older age groups apparently due to a decrease of elasticity in the arterial wall which starts gradually after the age of twenty (ROSSLE & ROULET 1932) The meandering phenomenon and the loss of elasticity in the blood vessel wall probably explain the

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Table

Age distribution of patient material

	Years						
	0–10	11–20	21–30	31–40	41–50	51–60	61–70
Number	0	12	22	14	21	23	8

tortuosity of most vessels in adults Other effects may however cause the vessel to leave its physiologically most suitable straight course after the confluence or before the division of certain vessels This may be apparent after the union of the vertebral arteries to form the basilar artery The irregular appearance of this vessel starts early and may be detected in the foetus

A small investigation of vertebral angiographies indicated that the course of the basilar artery was caused by three main factors namely (1) the loose connections between the basilar and the vertebral arteries and the surrounding tissues (2) the difference between the blood flow in the right and left vertebral arteries and (3) the directions of these blood flows compared to each other and the most natural course of the basilar artery along the mid sagittal plane of the skull By estimating the blood flows through the vertebral arteries and their directions just before the confluence of these vessels, it should be possible to make rules to indicate the probable direction of the basilar artery The course of this artery could perhaps be utilized more frequently in the diagnosis of expanding processes in the posterior cranial fossa

Material and Method The course of the basilar artery and the diameters of the vertebral arteries were estimated from two different sources (1) Angiograms obtained by the injection post mortem of a barium contrast medium into the cerebral arteries of 8 foetuses from 15 to 49 centimeters in length (2) Films from 100 normal vertebral angiographies

All the foetal vessels examined were well demonstrated in all the angiographies The films from the patient material were choosen according to the following rules (A) The angiography had to be carried out with a catheter introduced into one of the vertebral arteries following transfemoral percutaneous puncture (LINDGREN 1956) (B) Adequate demonstration of the basilar artery and the upper parts of the vertebral arteries (usually from the first cervical vertebra) was necessary (C) The angiograms must have been obtained in satisfactory projections (at least one true a p or one half axial film)



Fig 1 Accessory lines utilized during the measuring procedure Vertebral artery diameters were measured at d and the distance between the midline of the basilar artery from b to the mid sagittal plane a—a and the vertebro basilar junction to the same plane

The age distribution of the patients appears in the Table

The course of the basilar artery was determined by measuring the distance from the mid sagittal plane of the skull to (a) the midline of that part of the vessel with the greatest deviation, (b) the union of the vertebral arteries and (c) the division of the basilar artery (the bifurcation) The side of the mid sagittal plane on which these points were situated was noted (Fig 1) The diameters of the vertebral arteries were measured following a method described for the carotid artery by GABRIELSEN & GREITZ (1970) As it was not always possible to measure the diameters of the vertebral arteries exactly at their union with the basilar artery diameters for this purpose were selected from about 1 to 2 centimeters below the vertebro-basilar junction

No measurements of the basilar artery were made in the foetal angiograms only its appearances being recorded The diameters of the vertebral arteries were measured in two such angiograms in magnifications made with a communication set (H Q Vidicon camera-chain, Type EL 810 815 Philips) The measurements stated in millimeters were obtained by measuring the magnified vessels directly on the TV screen Sixteen vertebral angiographies from the patient material with small differences of the vertebral artery diameters were selected The angle between the mid sagittal plane and the direction of the vertebral arteries in their last sections before their union were measured with a protractor



Fig. 2. Foetal angiograms. a) Basilar artery with a straight course. b) Smallest foetus with slight deviation of the basilar artery. c) Largest foetus with marked arched deviation of the basilar artery.

Results

The course of the basilar artery was completely straight in six of the eight foetal angiographies (Fig. 2 a). The diameters of the left and right vertebral arteries as well as the inflow direction towards the basilar artery were symmetric in these six cases. In one of the foetuses, the smallest one (15 cm), the basilar artery deviated slightly to the right; the diameter of the right vertebral artery was 3 mm while that of the left was 3.5 mm as measured on the TV screen.

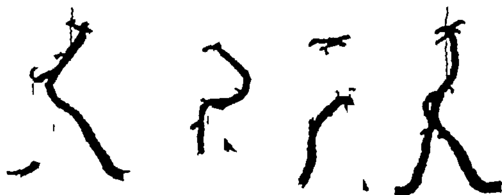


Fig. 3. Four basilar arteries apparently not conforming to the rule of deviation. The [illegible] some of the vertebral arteries may be explained partly by ectatic elongation of the vessel.

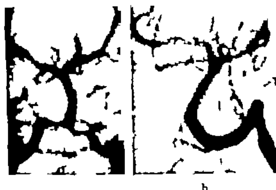


Fig 4 Vertebral angiograms Example of common arched displacement of the basilar artery caused by the blood flow of the greater vertebral artery (See also Fig 5)

(Fig 2 b) The largest foetus (49 cm) had a basilar artery with a large arched deviation to the right and displacement of the bifurcation in the same direction The vertebro basilar junction appeared to be situated in the mid sagittal plane the diameter of the right vertebral artery was 3 mm while that of the left was 8 mm (Fig 2 c)

The vertebral artery had the same diameter on both sides in five patient angiographies the angles between these vessels and the mid sagittal plane were identical and the basilar artery was straight Arched deviation of the basilar artery to the side opposite to that of the larger vertebral artery was evident in 78 patients

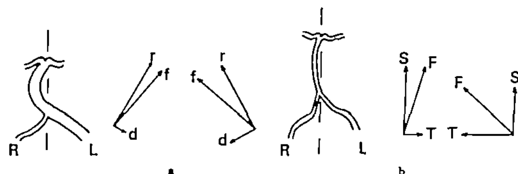
The angle between the vessels and the mid sagittal plane was measured in 12 patients with no or very small differences in the diameters of the vertebral arteries It was apparent that the basilar artery deviated to the side contralateral to the vertebral artery that formed the largest angle to the mid sagittal plane

The course of the vessels did not seem to follow these simple rules in the 4 cases illustrated in Fig 3

The course of the vertebral and basilar arteries was even more complicated in a further case however this patient was operated upon for a right sided carotid aneurysm before the vertebral angiography was performed which may have influenced the position of the vessels

Discussion

The primary pre requisite for the basilar artery to become tortuous is loose connections between the vessel and the surrounding tissues This factor however only allows the vessel to be more easily influenced by the haemodynamic forces — the amount of blood flowing through the vessels per unit time the velocity of



F g 5 The influence of blood flow forces w th different blood flows through the ertebral arteries and counter directions of flows a) The same blood flow but different opposed d rec tions of flow) r= rate of blood flow d and d diameter of ertebral artery f and f approximated blood flow forces The basilar artery will be forced by f to the right b) F = F May be divided into sagittal forces S and S and transversal forces T and T The basila rtery will be forced by T t the right

the blood flow and the direction of inflow into the basilar artery The basilar artery may therefore be shaped according to the influences of these forces As the vertebral arteries arise from the same primary vessel the aorta and join to form one single vessel variations in blood flow through them relate to differences in their diameters The direction of the blood flow which is determined by the direction of the vessel is reflected by the angle between the vertebral artery and the mid sagittal plane as evident in the a p projection It was thus possible in a simple manner to judge approximately the size and direction of these blood flows

Basilar artery deviation proved to be related to the diameters and directions of the distal parts of the vertebral arteries The most common cause of deviation was a difference in blood flows (Fig 5 a) The blood flow force acting on the basilar artery may depend upon the flow rate (r and r) and the amount of blood streaming through the vessels Since the rate of the blood stream through the vertebral arteries is probably similar on both sides the only variable will be the diameter of the vertebral artery and thus the cross sectional area of this ves sel (d and d) d is larger than d and therefore the resultant f will be smaller than f The force of the blood stream on the left side will be greater than that on the right side to which the basilar artery will deviate

The second cause of basilar artery deviation is illustrated in Fig 5 b The blood flows through the vertebral arteries were similar but the left vessel was more angulated to the mid sagittal plane than the right The blood flow forces F and F" were similar they may be divided into one sagittal and one transverse force The left vertebral artery transverse force T will then be greater than the right one T and the basilar artery will, therefore, deviate to the right

No difference in the diameters and angles of the vertebral arteries were established in 5 patients and the basilar artery ran a straight course In the largest group of 78 patients arched deviation of the basilar artery counter to the direction of the largest vertebral artery blood flow was present with marked differences in the diameters of the vertebral arteries The appearances of the basilar artery in these two groups made up of 83 of the total of 100 patients indicated that it is primarily the blood flow through the vertebral arteries that determines the deviation of the basilar artery (Fig 4) This is also illustrated by the appearances of the vessels in the foetal angiograms (Fig 2)

Twelve patients had very slight differences in the vertebral artery diameters and thus small variations between the blood flows through these vessels It was possible though to detect a relationship between the angles of the vertebral blood vessels to the mid sagittal plane and the deviation of the basilar artery This vessel thus deviated counter to the side of the vertebral artery forming the largest angle to the mid sagittal plane

In only 5 patients did the vessels have such appearances that it was impossible to state the cause of the deviation of the basilar artery from only the factors given above One of these patients had been operated upon for an aneurysm of the right carotid artery and it was impossible to judge the changes the intervention had caused intracranially The course of the basilar arteries in the other patients seemed to defy categorizing as to cause (Fig 3) If however the positions of the vertebral arteries in relation to the mid sagittal plane were ignored it was evident that the shape of the basilar artery was still determined by the amount of blood flowing through the vertebral arteries and the directions of these blood flows just before the vertebro-basilar junction

The investigation in the foetuses indicates that the shape of the basilar artery may be established early It was possible in these angiographies to correlate the relationship between the appearances of the vessels and the above mentioned haemodynamic forces The fact that most angiographies in the foetal material depicted a basilar artery with a straight course was probably due to the circumstance that the vessels were usually not completely developed and the diameters were thus still small The differences in the diameters and blood flows were therefore also small and had little influence on the course of the basilar artery When proportionally similar differences in vessel diameters and angles occur in foetuses and in adults the variation in flow rates in absolute figures for a given deviation will be greater in adults and a correspondingly greater increase of basilar artery displacement will result Ectatic changes in the foetal vessels following lack of elasticity in the arterial wall is not to be expected furthermore deviation of the basilar artery exists in an early stage of development It therefore appears reasonable to suggest that ectatic changes are of secondary importance in the forma

tion of these displaced vessels Because of limited patient material no correlation between age and increased deviation of the basilar artery was attempted, though probability speaks in favour of increasing deviation with increasing age due to ectatic changes It is likely that the tortuosity of the vessels illustrated in Fig 3 was due at least partly to ectasia causing their marked elongation The arched course in two of these cases definitely conforms however with the direction of flow in the vertebral arteries

Conclusions

Two main factors seem to determine the course of the basilar artery in normal subjects (1) the amount of blood streaming through the vertebral arteries as sessed by measuring the diameters of these vessels in their terminal sections just before their union to form the basilar artery (2) the direction of the blood stream through the terminal parts of the vertebral arteries determined by mea suring the angle between the midline of each vessel and the mid sagittal plane of the skull

The basilar artery courses away from that vertebral artery with the largest blood flow and the steepest angle to the mid sagittal plane

SUMMARY

The appearances of the basilar artery were examined post mortem in 8 foetal angio graphies nd in films from 100 vertebral angiographies considered normal The commonly rched displacement of the artery to one side seemed to be due mainly to differen in blood flow through the ertebral arteries and t direction in relation to the mid sag tal plane of the skull

ZUSAMMENFASSUNG

Die Erscheinungsformen der Arteria basilaris wurden post mortem in 8 fot len Angio graphien und an F lmen on 100 b normal befundenen ertebralen Angiographien unter sucht Die ge ohnlich gebogen Verschiebung der Arterie nach einer Seit scheint h upt sachlich uf dem Unterschied im Bl tstrom durch die Vertebralarterien und der Richtung im Verhaltnis zum Mitten Sagittalplan des Schadels zu beruhen

RÉSUMÉ

L teur a examine les aspects du tronc basilaire sur huit ngiographies post mortem de foetus et sur des f lms de 100 angiographies ertel ales con iderees comme norm les Le deplacement frequent en arc d cette rtere vers un coté p rait du principalement à une difference du courant sanguin dans les artères vertebrales et à sa direction par rapport au plan sagittal median du r ne

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EEG ECG AND OTHER RECORDINGS IN CEREBRAL ANGIOGRAPHY

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Cerebral angiography is not completely without risk as many of the subjects are old and suffer from vascular disorders. Careful observation of neurologic reactions is therefore important and routine recordings of EEG and ECG and sometimes of the EMG, blood pressure and respiration as well are required in most of the examinations. Patients considered to be susceptible to complications have been primarily selected for this investigation, the results of which to 1967 have been previously reported (LUNDERVOLD et coll. 1964, LUNDERVOLD & ENGESET 1966, 1969, LUNDERVOLD & ONORT 1968), while those for 1968 to 1971 are now presented.

The dose of contrast medium, reduced from 10 to 7 ml in December 1964, was again *increased to 9 ml in order to take advantage of the improvement* in technique and the reduction in complications achieved since 1962. This was possibly the cause of a slight deterioration in the polygraphic parameters as well as of an apparent increase in reactions. Intensive clinical control of all patients was instituted to examine this more thoroughly. The EEG and ECG were recorded in most of the patients. The results to the middle of 1972 are now reported and compared with the routine polygraphic investigations up to six months previously.

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Table 1

Findings in polygraphic recordings 1968 – 1971

Year	Total	Men	Women	Total inj	Carotid angiography	Vertebral angiography	Aortography	Changes EEG		ECG	
								No		No	
1968	438	239	199	768	334	71	33	3	0 38	3	0 38
1969	4 3	269	154	673	297	88	38	1	0 15	1	0 15
1970	550	344	206	854	450	106	14	5	0 59	0	0
1971	698	416	282	921	467	190	11	12	1 30	2	0 27
	2109	1268	841	3238	1628	38	96	21	0 65	6	0 19

Method and material Percutaneous transfemoral introduction of either a standard carotid catheter i d 0 47 mm or a vertebral catheter i d 0 45 or 0 47 mm was performed Special catheters were used for infants and small children It has seldom been necessary to puncture the carotid artery The patient was premedicated with atropine and amobarbitalum with mannitol if increased intracranial pressure was probable Only children and nervous adults were anaesthetized Isopaque Cerebral was injected in a dose of 5 ml for vertebral angiography and of 7 ml for carotid angiography this was increased gradually to 9 ml in 1970 but reduced again to 7 ml from early 1972 because of a slight increase in complications

Routine polygraphic recordings were made in 2 109 patients (1 268 men and 841 women) with a total of 3 238 injections during the period 1968 to 1972 (Table 1) The intensive clinical control covered 554 patients (323 men and 231 women) for 13 months to the middle of 1972 Of these 42 had simple aortographies and the remaining 512 patients had selective angiographies in which more than one vessel was usually examined at the same session A total of 419 patients (75 6 per cent) had a dose of 9 ml and the 135 patients (24 4 per cent) who followed had 7 ml of medium The EEG and ECG were also recorded for most of these patients and this material is included in the result of the routine polygraphic recordings before the end of 1971 some overlapping of the material compared thus occurred

The changes during the routine recordings in the period have been below 1 per cent for both the EEG and ECG except in 1971 when the percentage for the EEG increased to 1 3 (Table 1) This was the first full year at the increased dose (9 ml) and the raised frequency was the reason for instituting the clinical

control. Twenty five of the 554 patients in the control had temporary and usually short lived reactions. Four of these were allergic reactions to the contrast medium (urticaria), two were reactions to the local anaesthetic, and another patient had an attack of angina pectoris during the preparations for the radiographic examination; in four of the remaining 18 cases the reactions occurred before injection of the contrast medium, giving a frequency of 3.2 per cent.

Most complications occurred between the ages of 40 to 60 years; nearly all the patients examined were also in this range. The youngest with complications was 23, and one case with paralysis was only 25 years old. The frequency of complications was surprisingly higher in women (14 out of 231) than in men (only 4 out of 323). This is difficult to explain. A total of 18 reactions were recorded, none in patients who had had a general anaesthetic. Four of the reactions arose before the contrast medium was injected, and it is reasonable to assume that they were due either to manipulation of the catheter and possible dislodgment of emboli, or to the triggering off of some form of vasomotor effect. One of the patients had one of his recurrent epileptic fits which presumably had no connection with the examination itself. A probable cerebrovascular defect was present before the examination in 2 of the patients while another had recently been operated on for subarachnoid bleeding; all 3 were in poor condition. The fourth had a possible tumour or arteriovenous malformation and had previously undergone cerebral angiography without any complication.

One of the 14 reactions that arose after the procedure was due to haemoplegia caused by the subintimal injection of the medium and partial occlusion of the carotid artery; the paralysis disappeared after about a day.

There thus remain 13 patients in whom it is possible that the reaction may have been produced by the contrast medium itself in addition to any other factors. Only 2 of these reactions occurred after the reversion to the dose of 7 ml and were only trivial (nausea and vomiting). The group is however small and more serious reactions have been observed with this dose after the present material was completed. The duration of the effects was short, from minutes to a few days, except in a patient with slight dysphasia and facial paresis in whom they lasted three weeks; thus no patients had demonstrable permanent sequelae. Fifteen reactions were observed in the roentgen department while 3 were first noticed after the patient had returned to the ward. Eight of these patients had complications that were so slight and of such short duration that they would almost certainly have been missed if the intensive clinical control had not been made. This emphasizes that close control of the patient during and immediately after the roentgen examination is essential. BESSIE et col. (1971) have also reported slight, transient neurologic reactions that would have passed unnoticed if they had not been specially sought.

Tabl 2

Incidence f reactions before and after reduction of contrast dose from 9 to 7 ml

React on	No of patients	N of record ngs	No of EEG worse	No of EEG normal or unchanged	Not recorded
A Do 9 ml					
Hemipares paralysis or phasia	6	4	4	0	2
V sual d sturbances	5	4	1	3	1
N usea	1	1	1	0	0
B Dose 7 ml					
Nause or dizziness	2	2	1	1	0
Total	14	11	7	4	3

Polygraphic recordings were made as a routine usually before during and after the injection in patients in poor condition and those in whom experience had indicated might have been the most liable to reactions A detailed description of the technique and the previous results appears in earlier publications by the authors (LUNDERVOLD & ONGRE 1968 LUNDERVOLD & ENGESET 1969) Most patients had one or more routine EEG recordings before the neuroradiologic examination and some patients had these following it as well

Two of the 4 patients with neurologic reactions before the injection were examined polygraphically The EEG in one patient revealed focal changes as delta activity and spikes over the right frontoparietal region this is in agreement with the occlusion of the right internal carotid artery which was subsequently confirmed radiologically The EEG disclosed generalised dysrhythmia in addition to the focal changes when the patient became unconscious before the injection the condition was improved rather than deteriorated by the administration of the contrast medium (9 ml) The other patient had been operated on for an aneurysm of the left anterior cerebral artery The EEG before the radiologic examination indicated generalised cerebral dysrhythmia Before the cerebral angiography the patient had an epileptic attack and was unconscious for a d This had apparently happened before so that the relation to the roentgen examination was doubtful EEG recorded several days later revealed moderate focal delta activity over the left frontotemporal region

Eight of the 14 patients with reactions after the injection had prev u ly had EEG before 8 during and 9 after the examination was completed However only five reactions were recorded before during and after the xamination

Four reactions were recorded twice and 2 only after the examination; 3 were not recorded at all (Table 2). EEG recordings were made before, during and after the examination in 4 of 6 patients with hemiparesis, paralysis or aphasia; all became considerably worse. The EEG in a patient with N. abducens paresis was normal before the examination but the injection provoked left hemiparesis with dysphasia that lasted for three weeks and the EEG revealed theta activity over the central part of the right hemisphere. A patient with epilepsy had spike wave complexes without asymmetry in the EEG before the roentgen examination. Transient right hemiparesis appeared after the injection of contrast medium (into the left carotid artery) and lasted for about half an hour. Both the polygraphic and a subsequent EEG recording disclosed focal theta activity and reduced background activity over the left side, especially in the temporal region. One patient had been operated on three years earlier for a meningeoma of the right frontal region. Before the radiologic examination the EEG disclosed a marked delta focus with individual sharp waves over the right frontotemporal region; this increased after the subintimal injection of contrast medium to produce left hemiparesis of about 24 hours duration. Another patient, one with a pharyngeal neoplasm, had aphasia for two days after the injection with evidence of focal activity over the left temporal region in the EEG.

Five patients had visual disturbances some minutes after the injection. Moderate generalised cerebral dysrhythmia was evident in the EEG during and after the injection in one of these with a meningeoma of the right posterior fossa. The only symptom in the remaining 3 patients was slight nausea or dizziness for some hours up to 3 days; in one the EEG was unchanged and in the other two slight deterioration occurred in the form of generalised cerebral dysrhythmia.

Discussion

The complications of cerebral angiography (most commonly transitory hemiparesis with carotid angiography and disturbances of vision and consciousness with vertebral angiography (HAUGE 1954)) have been variously reported to be from 2 to 19 of a temporary and 0.8 to 3.7 per cent of a permanent nature (FIELD et coll. 1962; PATTERSON et coll. 1964; LAVERAS & WOOD 1964; TERRET & NISHIOKA 1966). SILVERSTEIN (1966) has pointed out that patients over 60 and those with cerebrovascular disease or other cardiovascular lesions carry an increased risk. Since 1962 the frequency and severity of complications have steadily decreased in our department from 16 per cent with changed ECG to 1 per cent in 1967 and from 19 per cent with EEG changes to 2 per cent in 1967. These have further decreased to less than 1 per cent in the period now reported except when the dose was increased. It would appear that this reduction in the

frequency of reactions has been due to an improved technique and better contrast media The importance of reducing the dose of medium to the minimum was stressed by LINDERVOLD & ENGESET (1966) who reported that the incidence of EEG and ECG changes decreased when the dose was lowered from 10 to 7 ml They also demonstrated a reduction in EEG and ECG changes when Isopaque 45 % (sodium metrizoate no longer marketed) was replaced by Isopaque B (sodium metrizoate balanced with calcium and magnesium) and a further reduction when Isopaque Cerebral was introduced compared with Isopaque B and Urografin The number of injections has also been decreased now that films are taken in two planes simultaneously

Since the incidence of complications had become so low a trial was made of raising the dose again from 7 to 9 ml The frequency of complications then appeared to increase so that the dose had to be returned to 7 ml The increase in complications could have resulted from more patients with cerebrovascular disease or otherwise in poor condition This could not however have been concluded with any certainty

Conclusion

The continuous polygraphic recording of patients considered most likely to suffer complications from cerebral angiography in the period 1968 to 1971 has confirmed the constant decrease in the frequency of EEG and ECG changes except for 1971 when a slight increase possibly associated with an increase in dose made at the end of 1970 was noted Extensive and detailed clinical examination of all cerebral angiography patients over a period of 11 months has disclosed 18 out of 554 patients with temporary most often short lived reactions such as hemiplegia aphasia and visual disturbances Many of these reactions would never have been noticed but for the close clinical observation in the roentgen department Such control, together with polygraphic recording should reveal the slight transitory reactions that occur These may possibly increase with the more active approach to the surgery of aneurysm and to operations on older subjects as well as on those in poor condition

SUMMARY

Recordings of EEG ECG and also occasionally of EMG and blood pressure during cerebral angiography performed in 2 109 patients during 1968 to 1971 have revealed reduction in the occurrence of abnormalities when compared with the 1 000 patients examined before 1967 and reported in 1969 Polygraphic recordings have now shown minimal changes in less than 1 per cent A more extensive clinical control of the patients revealed some slight transitory reactions not all seen in the recordings The significance of the type and amount of contrast medium is discussed

ZUSAMMENFASSUNG

Registrierungen des EEG EKG und auch gelegentlich des EMG und des Blutdrucks wahrend der cerebralen Angiographie die bei 2 109 Patienten zwischen 1968 und 1971 vorgenommen worden waren ergaben ein ermindertes Auftreten von Komplikationen verglichen mit den 1 000 or 1967 untersuchten Patienten woruber 1969 berichtet worden ist D e polygraphischen Registrierungen zeigten jetzt minimale Veranderungen bei weniger als 1 % Eine genauere klinische Kontroll der Patienten ergab einige leichtere or bergehende Reaktionen die nicht alle bei den Registrierungen zu sehen waren Die Bedeutung der Art und Menge des Kontrastmittels wird besprochen

RÉSUMÉ

Les enregistrements d EEG d ECG et aussi dans certains cas d EMG et de la pre sion sanguine cours d l angiographie cérebrale ffectues chez 2 109 patients entre 1968 et 1971 ont mont e une reduction d la freq ence des anomalies par comparaison vec les 1 000 patients examines avant 1967 et publies en 1969 Ces enregistrements polygraphiques ont montre actuellement des modifications minimes dans moins de 1 % des cas Un cont l clinique plus complet des malades a montre quelques reactions transitoires legeres qu n eta ent pas toutes mises en ev dence par les enregistrements Les auteurs exam n nt l importance d type et d la quantit de moyen de contraste

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ABDOMINAL DIMENSIONS AND THICKNESS OF THE SUBCUTANEOUS FAT IN THE FETUS

U Erasmie and H G Ringertz

Appreciation of the thickness of the fetal subcutaneous fat constitutes part of the roentgen assessment of fetal maturity The literature appears to contain no roentgen investigation of the subcutaneous fat layer of the fetus in the later stages of pregnancy this applies both to fetus of normal and diabetic mothers Ringertz (1971) described a method for determining fetal weight by roentgen measurements of the abdominal diameter (A) and the lumbar vertebral length (V) It was believed that the quotient A/V might be of clinical significance in, for example, maternal diabetes neonates of diabetic mothers have higher average weights than normal newborns (Hsia & Gellis 1957) and this might be associated with different body proportions The thickness of the abdominal subcutaneous fat and the A/V quotient were consequently investigated

Material and Methods The normal appearances and magnitude of the above factors were investigated in 130 cases in which (1) no abnormalities of mother or child had been recorded (2) the uterus contained no more than one fetus The roentgenograms were reviewed in retrospect The reason for the examination was usually uncertainty about the length of gestation and risk of overdue

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Fig 1 Roentgenogram of fetus in the tenth gestational month Measurements of the abdominal diameter (A) and lumbar vertebral length (V) (long arrows) and the thickness of the subcutaneous fat at the level of L1 (short arrows)

delivery Roentgenograms of 36 fetus of diabetic mothers were also analysed No attempt at subdivision of this group was made neither as regards the severity of maternal diabetes nor type of treatment All mothers were carefully controlled during pregnancy and thus probably on adequate drug therapy

The average calculated weight (RINGERTZ 1971) at the roentgen examination was 3 304 ± 561 g for the normal cases The corresponding figures for the fetus of diabetic mothers were 3 253 ± 631 g

All measurements were made from routine films in millimeters with an estimated error of under one millimeter No enlargement factor has been accounted for in the calculations The only roentgenogram used was obtained with the mother lying on her side with a compressor reducing the depth of tissues to be penetrated by the rays (EDHOLM 1956) The vertical focus film distance was 100 cm

The measurements of the fetal abdominal diameter (A) and the lumbar vertebral length (V) (RINGERTZ 1971) as well as the thickness of the subcutaneous fat at the level of the first lumbar vertebra perpendicular to the spine were recorded (Fig 1) This thickness could be measured on both sides of the abdomen in 93 and on one side in 37 normal cases The corresponding figures in the diabetic group were 28 and 8

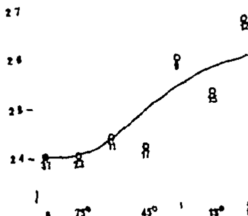


Fig Plot of the average A/V quotient (y axis) for different rotational aspects of the fetus (axis) The figures represent number of measurements included in each mean The curve indicates the best least squares fit to the values giving average transverse t sagittal abdominal diameter proportions of 1 084 1

The angle of rotation of the fetal body around its long axis relative to the mother was estimated The appearances of the fetal skeleton determined the grouping of the cases 0 (37) 15 (23) 30 (11) 45 (18) 60 (9) 75 (18) and 90 (14) The figures within brackets indicate the number of cases in each group 0 stands for an a p projection of the fetal body and 90 for a true lateral view

The calculated weight (RINTOMETZ) and not the birth weight was used through out The reason for this approach was (1) the time interval between the roentgen examination and the delivery was over one week in 52 cases and often several months with the smaller fetus (2) when applied in practice the birth weight will not be known at the time of examination

The correlation between the estimated and the observed weight was 0 71 for the 78 cases with less than one week between examination and delivery The average discrepancy between the calculated and the true weight was 288 g

Results

The corrections of the A/V quotient that were necessary for (1) varying fetal weight and (2) angle of rotation around the long axis of the fetal body relative to the mother in normal cases were determined separately

The average A/V ratio for groups of normal fetus within 500 g weight inter vals were calculated A compilation of these average values revealed a reduction in the quotient of 0 12 per 1 000 g increase in estimated weight This means that the lumbar vertebral length increases relative to the abdominal diameter by around 3 per cent for each 1 000 g increase of fetal weight in the later stages of gestation

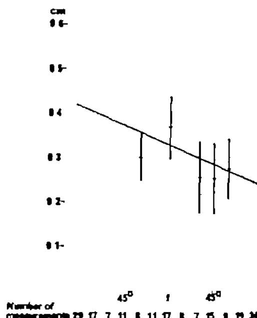


Fig 3 Average subcutaneous fat thickness (y axis) on both sides of the abdomen with standard deviations for different angles of rotation around the long axis of the fetal body (x axis) The best linear fit to the means has been drawn

The angle of rotation around the long axis of the fetal body would theoretically influence the A/V quotient if the cross section of the body at L1 had the form of an ellipse rather than a circle The values of the average A/V quotient in the different groups of rotation were calculated to confirm this so as to be able to calculate the proportions between the major and the minor axes of the ellipse (Fig 2) The values varied but suggested the elliptical form The proportion between the axes of the ellipse giving the best least squares fit was thus determined The following simplified formula was used

$$R = a\sqrt{(\tan v + 1)/(\tan v + a)}$$

in which R is the elliptic radius at an angle v to the minor axis and a is the proportions between the major and the minor axis of the ellipse The formula provides a good approximation of the exact value when a is close to 1 The resulting curve with $a = 1.084$ had the best least squares fit (Fig 2) As no variation in lumbar vertebral length with the angle of rotation was evident this means that the average transverse abdominal diameter of the fetus is 1 084 times more than the sagittal diameter'

The thickness of each of the two layers of abdominal subcutaneous fat was related to the angle of rotation around the long axis of the fetal body (Fig 3) The fat layer increases approximately linearly from the back to the umbilical line

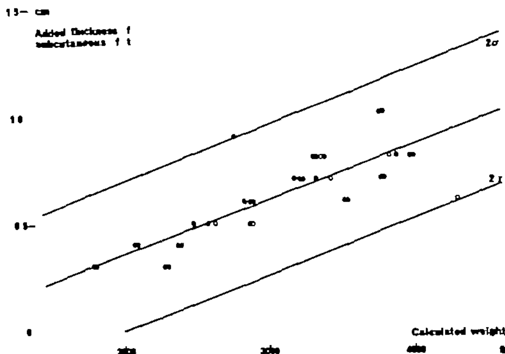


Fig 4 The added thickness of subcutaneous fat plotted against calculated weight for 93 normal fetuses Regression line and ± two sigma limits have been drawn.

The correlation coefficient of the means is −0 82 Thus the sum of the two measurable subcutaneous fat layers at the level of the first lumbar vertebra (L1) is fairly constant and independent of the individual angle of rotation The best value of subcutaneous fat thickness from the practical and theoretical points of view is thus the sum of the fat layers on each side of the fetal body obtained tangentially This added thickness was plotted against the calculated fetal weight and the 93 healthy cases in which the fat tissue could be measured on both sides of the abdomen were included The correlation coefficient is 0 71 and the mean deviation from the regression line for the average estimated weight 0 17 cm

Twenty four of the 36 fetus of diabetic mothers each had an A/V quotient below the average normal value corrected for the above mentioned factors the mean deviation was −0 05 One falling outside and over the two sigma limits Three of the 28 fetus of diabetic mothers in which the subcutaneous fat could be measured on both sides of the abdomen were outside the two sigma limits of the normal group (Fig 4) The distribution of the diabetic cases relative to these

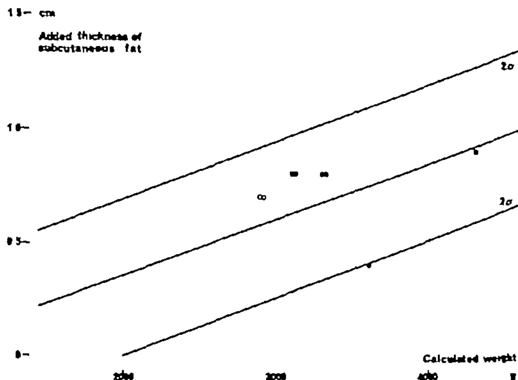


Fig 5 The added thickness of subcutaneous fat plotted against calculated weight for 28 fetus of diabetic mothers Regression line and ± two sigma limits from the plot of the normal cases in Fig 4

two sigma limits appears in Fig 5 A statistical analysis of the two materials of the added subcutaneous fat relative to the assessed fetal weight indicated no differences in the distribution

Discussion

The intention of this work was to find out if any differences might exist between fetus of normal and diabetic mothers in abdominal dimensions and the thickness of the subcutaneous fat The measurements were carried out in roentgenograms of the fetus This may introduce several foreseeable errors including a varying enlargement factor and position of the fetus Corrections for the influence of varying fetal weight and rotation in the uterus on the abdominal dimensions assessed were established to reduce these errors as much as possible The corrections were based on descriptive statistical methods and no analyses of significance were made The values are, however in part confirmed by a recalcu

lation of figures given by SCAMMON & CALKINS (1929). These authors published average sagittal and transverse body diameters measured at autopsy at the levels of the tenth rib and the umbilicus for 53 and 51 fetus respectively with a body length exceeding 40 cm. Recalculation of these diameters indicates that the average fetus was 1.082 times broader in the transverse than in the sagittal direction. The value of 1.084 obtained in the present roentgen examinations was thus strengthened.

Neonates of diabetic mothers present with a higher average weight than normal newborns (HSIA & GELLIS 1957), as previously stated. No obvious difference appears however to exist between these groups as regards the thickness of the subcutaneous fat or the quotient between abdominal diameter and lumbar vertebral length. One possible explanation is that the diabetic mothers were so carefully controlled and received such exact therapy that a possible effect of the diabetes on the fetal abdominal dimensions and the thickness of the subcutaneous fat was suppressed and thus not possible to detect by the technique of examination (MÖLLER 1970). RUSSEL & RANOECROFT (1969) have stated that a considerable acceleration of fetal skeletal growth occurs in fetus of diabetic mothers treated with drugs. The conclusion is that these fetus have a higher birth weight because of accelerated growth although they preserve abdominal proportions and thickness of subcutaneous fat in relation to body weight. This means that it will not be possible by roentgen examination to assess the potential influence of maternal diabetes on the fetus from the determination of abdominal dimensions or subcutaneous fat. A comparison between fetal maturity or weight and menstrual estimation of the length of pregnancy would appear to be the only means of determination. The thickness of the subcutaneous fat expressed as the sum of the appropriate layers on both sides of the abdomen at the level of L1 constitutes a significant positive correlation to estimated fetal weight. This would appear to be a useful quantification of a qualitative concept that has long been in use. The standard deviation of the normal values is however too large to permit the added thickness of the subcutaneous fat to remain more than a complement to other factors used in assessment of fetal maturity.

Theoretically the factors may be influenced by abnormalities other than maternal diabetes; dysmaturity comes to mind but an examination of its significance has not been made.

SUMMARY

Assessment of the abdominal diameter, length of the lumbar vertebra and the thickness of the subcutaneous fat revealed no obvious differences between the fetus of normal and diabetic mothers. It is concluded that the accelerated fetal growth and higher birth weight

of diabeti fetus are not normally accompanied by altered abdominal proportions or fat layer thickness The added subcutaneous f t at the level of the first lumbar vertebra con st tutes however a valuable means f determining fetal maturity

ZUSAMMENFASSUNG

Eine Abschatzung des abdominalen Diameters der Lange der Lumbalwirbelsaule und der Dicke des subkutanen Fettgewebes ergab kein klaren Unterschiede zwischen den Foeten normaler und diabetischer M tter Es wird daraus gefolgert dass der raschere foet le Zuwachs und das höhere Geburtsgew cht des diabetischen Foetus normalerweise nicht von veranderten abdominalen Proportionen oder Änderungen in der Dicke des Fettlagers begleitet wird Die Dicke des subkutanen Fettgehaltes in der Hohe des ersten Lumbalwirbels bildet jedoch ein brauchbares Mass zur Bestimmung der foetalen Reife

RÉSUMÉ

La mesure du diametre abdominal de l longueu de la colonne lombaire et d l epais seur de la graisse sous-cutanee n a pas montre de difference évidente entre les foetus d mère normale et d mere diabetique Les auteurs concluent que l acceleration d la cro sance foetale et l augmentation du poids de naissance des foetus de meres diabetiques sont habituellement pas accompagnees par des modifications des proportions d l abdo en ou d l epaisseur de la couche dipeuse L augmentation de la graisse sous cutanée nivea de la première vertebre lombaire constitue cependant un moyen interessant pour det miner la maturite foetale

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ELIMINATION OF DIATRIZOATE BY PERITONEAL DIALYSIS IN RENAL FAILURE

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High doses of contrast media containing iodine have proved to be of considerable diagnostic value for urography in renal failure (STAGE et coll 1971 1975) Normal subjects excrete diatrizoate almost exclusively by glomerular filtration (DENNEBERG 1965) Impairment of renal function delays excretion and increases extrarenal elimination which takes place mainly through the liver (HAMBSON & LINDHOLM 1963) STAGE et coll (1971) and MILMAN & STAGE (1974) demonstrated that high doses of diatrizoate in patients with renal failure may cause further deterioration in renal function, sometimes making rapid removal of the medium desirable The present investigation was therefore undertaken to assess the value of peritoneal dialysis for this purpose

Material and Methods The material comprised 5 patients with chronic renal failure with a mean 24 hour endogenous creatinine clearance of 3 7 ml/min (Table 1) None of the patients had any history of peritonitis intra abdominal surgery or hepatic disease Peritoneal dialysis was performed through a plastic catheter placed in the sacral fossa using the intermittent flow technique with an approximate cycle length of one hour (inflow 10 minutes, diffusion time 30

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Table 1

Data of patients and peritoneal dialyses. bef. d. = before dialysis, aft. d. = after dialysis, chron. pyel. = chronic pyelonephritis, chron. glom. = chronic glomerulonephritis

Case	Sex	Age (yrs)	Diagnosis	Endogenous creatinine clearance (ml/min)	Serum urea (mmol/l)		Serum creatinine (mmol/l)		Tonicity of dialysis fluid	Total excess outflow of dialysis fluid (outflow − inflow) (l)
					bef d	aft d	bef d	aft d		
1	F	38	Chron pyel	8 5	21	10	0 70	0 44	isotonic	3 0
2	F	50	Chron glom	0 5	49	14	1 23	0 61	isotonic	2 4
3	M	22	Chron glom	3 8	34	21	1 72	1 39	isotonic	2 3
4	M	36	Chron glom	3 0	13	8	1 38	0 95	hypertonic	3 3
5	M	26	Chron glom	2 8	28	15	0 94	0 62	hypertonic	4 4

Table 2

Peritoneal clearance and plasma T½ for diatrizoate before and during dialysis

Case	T½ for plasma diatrizoate (hours) before dialysis	T½ for plasma diatrizoate (hours) during dialysis	U/P ratio for diatrizoate	V (ml/min)	Peritoneal clearance for diatrizoate (ml/min)	Diatrizoate concentration in dialysis fluid as percentage of plasma value after 2 hours diffusion
1	23 1/2	9	0 29	47025/1370	10 3	69
2	62 3/4	15 3/4	0 28	42360/1200	9 9	63
3	46 1/4	13 1/2	0 25	38275/1105	8 7	
4	57 3/4	13 1/4	0 33	43325/1210	11 8	
5		13 1/4	0 2[illegible]	48373/1390	1[illegible] 8	71
	$\bar{x}$ = 47 1/[illegible]	$\bar{x}$ = 12 1/[illegible]			[illegible] = 10 7 ± 1 6	

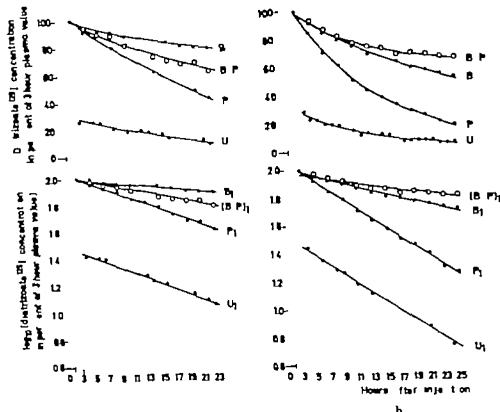


Fig 1) Case 2 b) Case 1 Concentration of diatrizoate in plasma and dialysate outflow B = plasma concentration before dialysis P = plasma concentration during dialysis B – P = (100 – (B – P)) = effect of dialysis on plasma concentration U = concentration in dialysate outflow B P1 (B – P) and U represent the corresponding curves in semilogarithmic co-ordinate system

minutes outflow 20 minutes) and a per cycle inflow of 2 l iso- or hypertonic dialysate at body temperature (Table 1) In 4 patients elimination of the diatrizoate was measured both before and during dialysis, and in one patient during the procedure

All patients received 20 μCi I labelled sodium diatrizoate intravenously in sodium and methylglucamine diatrizoate 76 % (Urografin 76 %) 1 ml/kg body weight as carrier Blood samples were drawn before the injection at 15 minutes 30 minutes 1 hour and then every second hour for the next 20 to 25 hours One ml of plasma was examined in 10 minutes in a well type scintillation counter so that the diatrizoate concentration could be measured Peritoneal

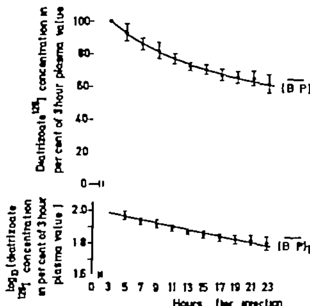


Fig 2 The effect of peritoneal dialysis per se on the elimination of diatrizoate represented by the fall in the concentration of plasma diatrizoate (mean of curves (B−P) in 4 patients ±1 SD)

dialysis was started one hour after the administration of the medium the volume of each dialysate outflow was measured and the diatrizoate concentration determined by examining 4 ml in 10 minutes Three hours after the injection of the diatrizoate, diffusion equilibrium in the extracellular space had taken place and the plasma concentration started to decline exponentially To allow comparison between the different series the plasma diatrizoate concentration for the 3 hour sample was always taken as a unit and the other values were expressed as percentages of this value

Peritoneal clearances of diatrizoate were calculated according to van Slyke's formula $Cl = \frac{U \times V}{P}$ in which Cl = clearance in ml/min, U = concentration in dialysate outflow P = plasma concentration, and V = dialysate outflow in ml/min Peritoneal diffusion curves of diatrizoate were obtained in 3 patients by the Boen method (1961) Blood samples were drawn at the beginning the middle and the end of the 120 minute long diffusion period while samples of peritoneal fluid were collected every tenth minute and the diatrizoate concentration measured

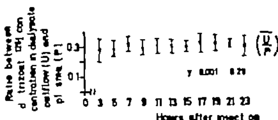


Fig 3 Mean U/P ratio for diatrizoate during dialysis in 5 patients ±1 SD

Results

The effect of peritoneal dialysis on the plasma half life (T1/2) of diatrizoate appears in Table 2 Dialysis reduces the mean T1/2 from 47 1/2 to 12 1/2 hours Fig 1 demonstrates changes in plasma diatrizoate concentration before (curve B) and during dialysis (curve P) together with the concentration in dialysate outflow (curve U) in Cases 1 and 2 The effect of dialysis on the elimination of diatrizoate is depicted by subtraction of the plasma concentration curve during dialysis from the plasma concentration curve before dialysis (curve B−P) calculated as 100−(B−P) B_1 P_1 $(B-P)_1$ and U_1 are the corresponding curves in a semilogarithmic co-ordinate system The mean B−P curve in 4 patients (curve $(\overline{B-P})$) appears in Fig 2 in a semilogarithmic co-ordinate system plasma concentration falls in a straight line indicating that the elimination of diatrizoate is a first order reaction, compatible with transport by diffusion The ratio between the diatrizoate concentration in the dialysate outflow and plasma (U/P ratio) was constant in each patient throughout dialysis (Table 2, Fig 3)

The peritoneal clearance for diatrizoate appears in Table 2 the mean peritoneal clearance was 10 7 ± 1 6 ml/min at a dialyzing rate of 2 l per hour

Fig 4 depicts diffusion curves (curve E) in Cases 1 and 2 After 120 minutes diffusion the concentration of diatrizoate in the peritoneal fluid was 63 to 71 per cent of the plasma concentration (Table 2)

In a semilogarithmic co-ordinate system the difference in diatrizoate concentration between the plasma and peritoneal fluids (curve $(D-E)_1$) falls in a straight line compatible with transport by diffusion

Discussion

The peritoneal cavity is lined by a semipermeable membrane with an area of about 2 2 m water and its solutes are transported across this membrane mainly by diffusion The permeability of the peritoneal membrane is increased by heat hypertonic solutions and infection (DUNEA 1971) The rate of diffusion

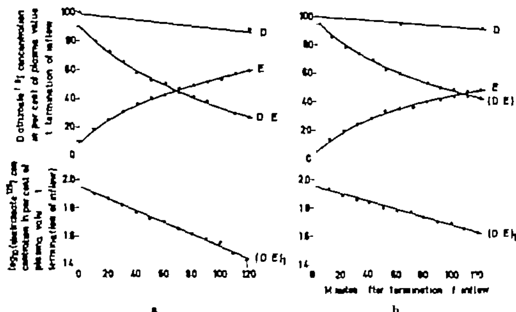


Fig 4 a) Case 1 b) Case 2 Diffusion curve for diatrizoate D = plasma concentration of diatrizoate E = concentration of diatrizoate in peritoneal fluid D−E = difference between concentration of diatrizoate in plasma and peritoneal fluid $(D-E)_1$ = D−E curve in semilogarithmic co-ordinate system

across the peritoneal membrane for a given substance depends, among other factors on the size of the molecule and the degree and strength of binding to plasma proteins According to LABBER et coll (1962) the protein binding of diatrizoate is negligible and the substance may for practical purposes be considered as freely diffusible

BAHLMANN et coll (1970) investigated the elimination of diatrizoate by peritoneal dialysis in 11 patients, by measuring the changes in the serum iodine The patients underwent peritoneal dialysis for 44 to 67 hours with 88—143 l of dialysate Serum iodine fell significantly in all dialyses Sixty one and 12 per cent of the dose were recovered in the dialysate and urine respectively The T1/2 and peritoneal clearance for the contrast medium were not estimated

Diatrizoate is easily removed by haemodialysis the T1/2 being about 4 hours (HANSSON & LINDHOLM 1963 and BAHLMANN & KRUSKEMPER 1973) The present results indicate that passive diffusion of diatrizoate is the most likely way of transport across the peritoneal membrane evidence of an active transport mechanism was absent BOEN demonstrated that the peritoneal clearance rises with an increasing dialyzing rate and that the clearances of urea and creatinine were about 22 ml/min and 13 ml/min respectively at a dialyzing rate of 2 l

per hour. The peritoneal clearance of diatrizoate in the present material appeared to be within the same order of magnitude as that of the creatinine. The high clearances in Cases 4 and 5 may probably be explained by the employment of hypertonic dialysate. BOEN reported that diffusion equilibrium between plasma and peritoneal fluid for urea was reached by 120 minutes. The mean concentration of diatrizoate in the peritoneal fluid in the present material was 68 per cent of the plasma concentration, indicating that the diffusion rate of diatrizoate across the peritoneal membrane is slow compared to urea.

The extrarenal excretion of diatrizoate through the liver and small bowel epithelium in subjects with normal renal function amounts to about 2 per cent of the dose given. Decreasing renal function causes increasing extrarenal excretion which in anuric patients may be as high as 50 per cent within 3 days after the administration of diatrizoate (VAN WAES 1972). DENNEBERG recorded a normal rapid rate of excretion with a plasma T1/2 for diatrizoate of less than 2 hours. Impaired renal function raises the T1/2 (VAN WAES) as confirmed by the present results.

Some authors (STAGE et coll. 1971 and MILMAN & STAGE) have demonstrated what they believed to be a nephrotoxic effect of diatrizoate. However this assumption has not yet received experimental support (BERG et coll. 1958, LINDGREN 1961). BERLYNE & BERLYNE (1962) suggested that it is possible that prolonged high concentration of the contrast medium, a situation occurring in patients with renal and hepatorenal failure, might be responsible for further renal injury. Considering the general efficiency of peritoneal dialysis the elimination rate of diatrizoate is acceptable from a clinical point of view, the peritoneal clearance being within the same order of magnitude as that for creatinine. Thus hepatorenal failure no longer seems to be a contraindication for the administration of high doses of contrast medium, provided facilities for dialysis are available. If a rapid elimination of diatrizoate is indicated haemodialysis is clearly superior to peritoneal dialysis.

SUMMARY

The elimination of diatrizoat by peritoneal dialysis was investigated in 5 patients with chronic renal failure, in 4 of these before dialysis as well. The method is a reliable although rather slow one of removing diatrizoat. Haemodialysis is to be preferred if rapid elimination is indicated.

ZUSAMMENFASSUNG

An fünf Fällen von Niereninsuffizienz wurde die Ausscheidung von Diatrizoat mittels peritonealer Dialyse untersucht, in vier Fällen auch vor der Dialysebehandlung. Die Methode ist obwohl langsam zuverlässlich. Die Hämodialyse ist vorzuziehen, wo Schnelligkeit erlangt werden muss.

RÉSUMÉ

L elimination du diatrizoate par dialyse peritoneale a ete etudiee chez 5 malades atteints d insuffisance rénale chronique chez 4 d entre eux elle avait éte etudiee aussi avant dialyse Cette methode est efficace bien que plutot lente pour eliminer le diatrizoat Il faut preferer l hemodialyse a l elimination du diatrizoate doit etre rapide

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INCREASE OF SUBCAPSULAR RENAL PRESSURE AFTER INTRAVENOUS IODIPAMIDE AND OTHER PARENTERAL CONTRAST MEDIA

An experimental investigation

P LINDGREN and G F SALTZMAN

Renal damage due to intra arterial injection of contrast media was a problem to be reckoned with in the roentgen diagnostic work during the late 40s and 50s The difficulties were especially apparent in the period when sodium acetrizoate (Urokon Triurol and others) was the dominating medium for angiography The introduction of sodium diatrizoate for this examination radically reduced the clinical renal complications After BERG et coll (1958) and LINDGREN (1961) had demonstrated experimentally the marked difference between the acetrizoate and diatrizoate preparations as regards renal toxicity renal complications in connection with intra arterial injections ceased to be serious

The armamentarium of contrast media still contains a medium with largely the same toxicity as the acetrizoate preparations namely iodipamide (Biligrafin Cholegrafin) for intravenous cholegraphy The introduction of ioglycamide

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(Bilivistan) as a contrast medium for cholegraphy has failed to bring about any radical change in this respect, despite its lower toxicity Iodipamide is not it is true, injected intra arterially but LINDGREN et coll (1966) have demonstrated that its intravenous injection may cause renal damage observable in both ex perimental and clinical roentgenographic examinations ALWALL et coll (1955) suggested that the intravenous injection of the now largely abandoned diiodized contrast media could contribute to the development of renal insufficiency

BERG et coll and LINDGREN observed enlarged and edematous kidneys after intra arterial injections of sodium acetrizoate LINDGREN also demonstrated that the circulation through the kidneys was considerably reduced when sodium acetrizoate was injected intra arterially Similar changes were reported by LIND GREN et coll (1966) after intra arterial injections of iodipamide Diatrizoate preparations also according to APERIA et coll (1968) have a slowing effect on the circulation when administered intra arterially

All the contrast media for parenteral administration cause as a rule after intra arterial injection varying degrees of peripheral vascular dilatation with attendant increase in the peripheral circulation The kidneys thus seem to con stitute an exception to an otherwise generally valid rule

LINDGREN et coll (1966) demonstrated that intravenous iodipamide injec tions also caused renal edema in an experimental material as well as renal en largement in a clinical series of cholegraphies The renal parenchyma is covered with a fairly inelastic capsule The fact that it was possible despite this inelasticity to observe a distinct renal swelling, prompted an investigation into the extent to which subcapsular pressure increase could be measured after an intravenous injection of iodipamide and furthermore whether this increase was such that it could explain the paradoxical decrease in the renal circulation

Material and Methods The effect of intravenous injections of clinical doses of contrast medium was investigated in 15 cats anesthetized with pentobarbital so dium intraperitoneally (30 mg/kg) supplementary amounts were administered when necessary during the experiment, a tracheal cannula was inserted to facil itate respiration The systemic blood pressure was measured in the left carotid artery which was cannulated and connected to an electromanometer (Statham P23AA) The recordings were made with a conventional polygraph Grass mo del 5

The left kidney was exposed through an incision in the [illegible] flank und r the last rib A cut 3 to 4 mm long was made i [illegible] ie renal caps [illegible] pproximat l at the middle of the ventral aspect of the [illegible] care bei [illegible] to p[illegible] ent bleeding and damage to the renal surface [illegible] h there [illegible] ut 1 mm) with a thin rubber bladder attached [illegible] was cau [illegible] be-

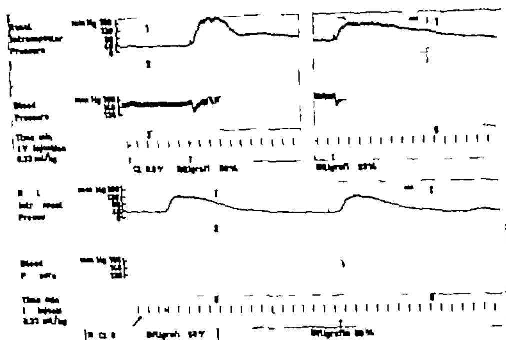


Fig 1 Cat 5 kg Changes in blood pressure and renal subcapsular pressure after intravenous injection of 0 33 ml/kg Bil vrafin forte The increases in subcapsular pressure were exceptionally high

tween the capsule and the surface of the kidney The tip of the catheter inside the bladder had a number of small holes so that the communication between the bladder membrane and the catheter would remain open even if the tip happened to come into contact with the bladder wall at any point The filling of the catheter and bladder with physiologic saline was made with great care to ensure that all air was eliminated The volume of saline in the bladder usually 0 05 to 0 1 ml was adjusted to keep the bladder walls completely slack so that they would not affect the pressure conditions through autotension The other end of the catheter was attached to a sensitive electromanometer (Statham P23BB) As the walls of the catheter could be considered as almost totally unyielding at the pressures under investigation the method implied that a completely closed fluid system had been produced in which the renal subcapsular pressure was transmitted to the electromanometer Only small volume variations thus occurred in the pressure receiving bladder with little liquid displacement in the system (displacement in the electromanometer 12 ml per 100 mm Hg) The recordings were made with the same polygraph as was used for the blood pressure measurements

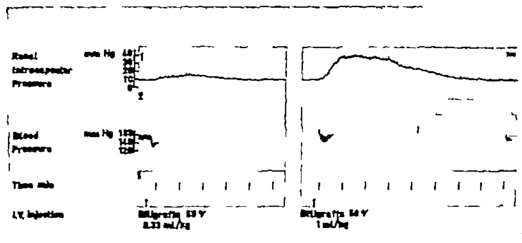


Fig 2 Cat 3 0 kg Changes in blood pressure and renal subcapsular pressure after intravenous injection of Biligrafin forte in two different doses

The following contrast media were given intravenously through a plastic catheter inserted in the cephalic vein in a foreleg Biligrafin forte 50 % (Schering) (methylglucamine iodipamide) Triurol 50 % (Leo) (sodium acetrizoate) Urografin 60 % (Schering) (sodium and methylglucamine diatrizoate)

Results

Effect of Biligrafin forte The blood pressure fall after a rapid intravenous injection of Biligrafin observed in earlier investigations was confirmed and was often considerable (Figs 1 3) The first injections in these experiments 0 33 ml/kg in both instances resulted in a fall of 30 and 50 mm Hg respectively

The initial values for the renal subcapsular pressure varied considerably in the different cats, usually lying between 10 and 30 mm Hg A control dose of physiologic NaCl intravenously in all the experiments produced no appreciable reaction Biligrafin forte on the other hand in a dose of 0 33 ml/kg usually produced a marked increase in pressure An experiment in which exceptionally high subcapsular pressures were recorded is illustrated in Fig 1 After 10 to 15 seconds, in other words the same latency period as for the fall in blood pressure a small initial rise in the subcapsular pressure was observed This subsided within about ten seconds but was followed by a second, steep rise which in the experiment illustrated in Fig 1 had within 1 5 minutes raised the renal subcapsular pressure to that of the arterial blood After a few minutes the subcapsular pressure fell again although only to a level corresponding approximately to twice the initial level (60 to 70 mm Hg as against roughly 30 mm Hg) nearly 1 5 hours elapsed before it had returned more or less to the initial level As earlier investiga

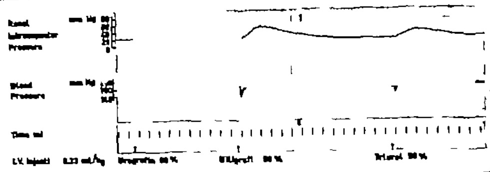


Fig 3 Cat 3 3 kg Changes in blood pressure and renal subcapsular pressure after intra enous injections of contrast media of 0 33 ml/kg Comparison between Urografin Biligrafin forte and Triurol

tions have indicated that the circulatory effects following the intravenous injec tion of Biligrafin forte display marked tachyphylaxis (BRISMAR et coll 1971) it was considered of interest to repeat injections of the same dose Three such injections were given at intervals of 15 to 20 minutes the interval between the first and second injections being 1 5 hours (Fig 1) The reaction to these injec tions was similar although the increase in the subcapsular pressure was slightly lower compared to its rise following the first injection the tachyphylaxis was not so marked however as it was for the blood pressure fall—the fourth injection caused virtually no fall at all

It should however be pointed out that while the quantitative variations be tween the different animals were considerable some degree of increase in the subcapsular pressure occurred in all of them One cat displayed inconsiderable reaction to 0 33 ml/kg Biligrafin forte (Fig 2) The fall in blood pressure was of the usual magnitude indicating that the blood pressure reaction and the change in the subcapsular pressure were not correlated quantitatively When the dose was increased—to 1 ml/kg in the experiment (Fig 2)—a more marked rise in the subcapsular pressure however occurred

As a considerable difference has been observed in the circulatory effects as well as in the renal enlargement in the groups between rapid and slow intra venous injection of Biligrafin, a few experiments with slow injection of the con trast medium (over 5 min) were also run no changes were observed in the renal subcapsular pressure or in the arterial blood pressure

Effects of other contrast media The difficulty of quantitatively evaluating the reactions if several injections were made and if different contrast media were used for them soon became obvious a few experiments were made never theless to gain further information Fig 3 illustrates the result obtained in one of

them in which a small dose, 0 33 ml/kg of three different contrast media, Urografin Biligrafin forte, and Triurol, were given intravenously in turn Urografin produced an inconsiderable rise in the subcapsular pressure, while Biligrafin forte and Triurol caused appreciable reactions both as regards a fall in blood pressure and an increase in the renal subcapsular pressure

Discussion

Considering the comprehensive literature on renal injury after intravenous and intra arterial injections of contrast media for urographic and angiographic examinations it would not be surprising to find that other media with the same form of administration could produce similar effects The bile duct contrast medium Biligrafin forte was therefore subjected some years ago to an investigation (LINDGREN et coll) it was then observed that an intravenous injection of Biligrafin forte produced a marked decrease in the renal circulation in cats Histologic examination revealed exceptionally severe edema in the renal parenchyma with considerable dilatation of the glomerular capsules and the tubules Transient renal enlargement was demonstrated furthermore, in cases that had undergone routine cholegraphies with Biligrafin forte given intravenously by rapid injection

It was these observations that motivated the present investigation which was undertaken mainly to obtain an objective method of measurement for a parameter—renal subcapsular pressure—that would be closely correlated with renal enlargement The results provide ample support for the view advanced earlier namely that Biligrafin forte, even in clinical doses may have a deleterious effect on the kidneys

It was interesting to observe the time relations between a subcapsular pressure rise and changes in the renal blood flow (cf LINDGREN et coll 1966 Fig 4) The rise in the subcapsular pressure set in after about 30 seconds, and the decrease in the circulation had a latency period of 40 to 50 seconds This strongly supports the previously expressed view that any decrease occurring in the blood flow after injection of a contrast medium with a circulatory action, such as of the iodipamide and acetrizoate types should not be interpreted as active vasoconstriction but rather as being due to other factors (LINDGREN 1961 LINDGREN et coll 1966) The reaction might first well be explained as a vasoparalytic effect heightened by a strong element of disturbed permeability with edema renal swelling increased subcapsular and intrarenal pressures, and a consequent retardation of the circulation Secondly there could be tissue hypoxia which in its turn increases the effects The physiologic relation between factors such as renal circulation and intrarenal pressure have been examined in detail by ÅSTRÖM et coll (1962) and ÅSTRÖM & SAMELIUS (1962) A contributory cause of the

changes might be the intravascular erythrocyte aggregation produced by Biligrafin forte (LINDGREN et coll 1964)

In view of the rapidity with which the rise in the subcapsular pressure took place, the disturbed permeability of the renal vessel walls ought probably to have been considerable That roentgenographic contrast media may cause disturbance in vascular permeability is recognized in the literature BROMAN & OLSSON (1956) for instance in a series of papers reported damage to the blood-brain barrier in connection with experimental carotid angiographies The increase in intracranial pressure described by KAOSTROM & LINDGREN (1960) was interpreted as another indication of disturbed permeability

It also seems worth drawing attention to the great individual variations in the observed reactions from the quantitative aspect Only in about one case were there pressure rises that could be described as being so high that they could reasonably have given rise to functional disturbances No conclusions as to the causes of the variations can be drawn from the present material there seems to be good agreement with clinical observations (LINDGREN et coll 1966) In that material too considerable variations from case to case were observed with respect to the kidney enlargement recorded Although the renal changes reported cannot be disregarded and although the fact remains that among the contrast media in general use Biligrafin forte seems to be the one with the highest toxicity the clinical risks should not be exaggerated and transient edema in the renal parenchyma in all probability and in most cases passes unnoticed Support for this view arises in the fact that apart from the kidney enlargement mentioned signs of renal damage in connection with cholegraphies have not been noticed in clinical practice

Acknowledgement

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SUMMARY

A simple method for recording the renal subcapsular pressure in cats is described Considerable increases in the pressure were observed after the intravenous injection of clinical doses f Biligrafin forte Their clinical significance and their relation to the changes after Biligrafin described earlier such as renal enlargement retardation f th renal circulation and the formation of edema are briefly discussed

ZUSAMMENFASSUNG

Es wird eine einfach Method zur Registrierung des subkapsularen renalen Drucks bei Katzen beschrieben Ein erheblicher Anstieg des Drucks wird nach intravenoser I jektion on klinischen Dosen on Biligrafin forte gefunden Die klinische Bedeutung und deren

them, in which a small dose, 0 33 ml/kg of three different contrast media Urografin, Biligrafin forte, and Triurol, were given intravenously in turn Urografin produced an inconsiderable rise in the subcapsular pressure, while Biligrafin forte and Triurol caused appreciable reactions both as regards a fall in blood pressure and an increase in the renal subcapsular pressure

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FROM THE DEPARTMENTS OF RADIOLOGY AND SURGERY S T GORANS SJUKHUS
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ANAL FISTULOGRAPHY

S AHLBACK, B HOLMSTRÖM and B SYK

Anal fistulography has seldom been described and appears to have been little used the latter has probably been due to the difficulty in defining the relationship between the fistula and the anal canal A special technique has therefore been employed to demonstrate the latter and the radiologic results have been related to clinical observations

Technique A Clausen rectal catheter with a balloon and a solid rubber ball delineates the anal canal (Fig 1) The balloon is inflated within the rectum so that the ball is pressed against the anus and the anal canal is defined in between The ball has a diameter fixed at 35 mm which makes it possible to correct the magnification in the roentgenograms for exact measurements Urografin 60 % is injected during fluoroscopy through a Nelaton catheter wide enough to occlude the external opening of the fistula a lead marker having previously been applied to the external opening Full-size films are taken in frontal lateral and oblique projections

Material This consisted of 98 fistulographies in 93 patients selected since they had been referred for special treatment most of the patients had been treated earlier at other hospitals

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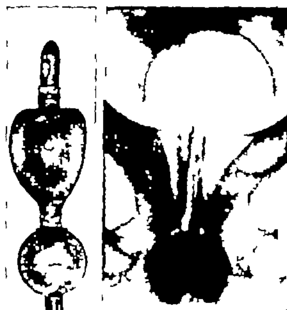


Fig 1 Clausen rectal catheter (in situ to the right) The theter delineates th anus Lead marker t external opening of th fistula

Anatomy and terminology The relationship between the fistula and the sphincter muscles is of considerable practical importance since the treatment in principle consists of establishing a wide communication of the fistula with the anal canal the partial severance of the sphincters must be performed with care for if too great it may produce incontinence (Fig 2)

The fistulas are classified clinically as low high and pelvorectal The boundary between low and high anal fistulas is the dentate line this is also called the

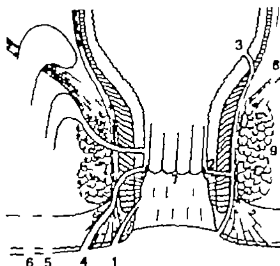


Fig 2 Relationship of various types of anal fistulas t the sphincter muscles (1) subcutaneous fistula (2) intermuscular low fistula (3) intermuscular high fistula (4) low anal fistula (5) high anal fistula (6) pelvorectal fistul Anatomic structures (7) dentate line (8) puborectalis muscle (9) anal sphincter (Published by courtesy of I his nd Acta chir scand)



Fig 3 Incomplete low anal fistula A p Contrast filling of an ischio-rectal cavity Perforation of the sphincter muscle (→) N inner opening nor contrast filling around the balloon

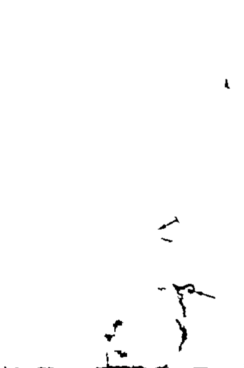
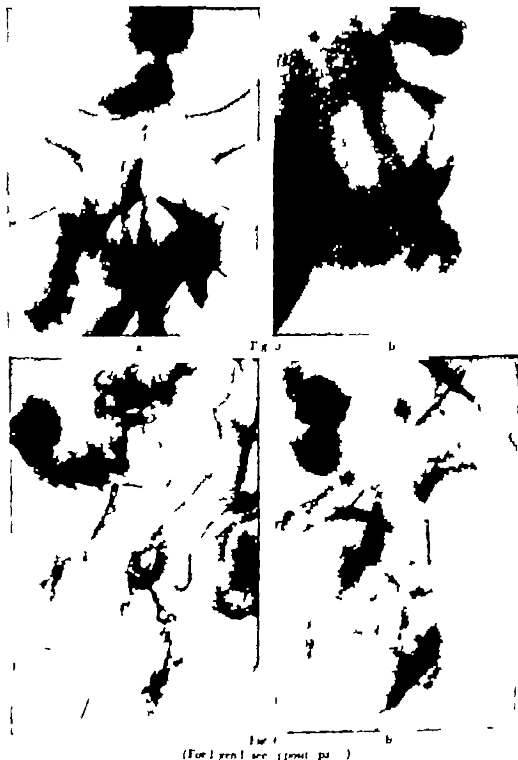


Fig 4 Complete high anal fistula Oblique projection External opening marked with lead strip (→) Inner opening (↦) 17 mm from the anus with contrast medium around the balloon

pectinate line or the anocutaneous line and represents the junction of the zones of the anal canal lined with stratified squamous epithelium and columnal epithelium respectively Since the dentate line is not radiographically demonstrable it was arbitrarily considered to lie 15 mm above the anus corresponding to its anatomic location The puborectal loop constitutes the boundary between high anal and pelvorectal fistulas This loop is that part of the levator ani that merges with the upper part of the sphincter this is also not demonstrable radiographically but experience has taught that it lies about 30 mm above the anus This correlated well with the clinical results although probably due to scar formation and deformity of the anus a slight discrepancy was sometimes observed



(For legend see opposite page)



Fig 7 Complete high anal fistula Conventional technique without marking of the anus ( ) The patient was referred with diagnosis of pelvorectal fistula The balloon catheter technique (b) revealed the correct diagnosis

Forty six of the 98 fistulas were radiographically complete with an internal opening (Figs 4 5) while only a perforation of the sphincter without any filling of the anal canal was evident in a further 24 cases (Fig 3) thus in about three quarters of the material the anorectal origin of the fistulas was revealed Two of the remaining 28 fistulas without demonstrable connection with the anorectal lumen were connected with diverticulae at a higher level in the sigmoid colon (Fig 6) while one was caused by septic spondylitis. The remainder were superficial or deep abscesses without demonstrable origin

The radiologic findings were confirmed by operation in 67 cases An internal opening was evident at operation however in a further 17 cases in which only a large perirectal cavity had been demonstrated An internal opening or a sphincter perforation was apparent radiographically in 10 cases but was not verified in 7 of these this was by reason of spontaneous healing of the external opening obviating surgery The internal opening had possibly closed between the roentgen examination and the operation in the remaining 3 cases Detailed operation notes were not available in 4 cases

Fig 5 Complete high anal fistula (horse-shoe fistula)) A p and b) lateral (sacrum to the right) These fistulae generally have the inner opening in the midline of the posterior wall The anal canal is deformed by abscess formation

Fig 6 Complete pelvorectal fistula) Left anterior oblique and b) lateral Fistula horse shoe shaped like the previous one but situated anterior to the anal canal and the rectum The patient had prostatitis Fistulography revealed that the fistula originated from the sigmoid colon (→)

Discussion

The surgical treatment of perianal fistulas demands that the internal opening be localized as the approach varies according to the level A simple lay opening procedure is sufficient in low anal fistulas but a more complicated operation often of a plastic nature, is necessary in high fistulas Rectal fistulas always need temporary colostomy followed later by local excision

Experienced proctologists have denied the need for roentgen examination of anal fistulas and have trusted solely in probing This may however be dangerous and actually is the most common cause of rectal fistulas Fistulography is often performed without delineating the anus, o that the presence of an inner opening although not its level, may be demonstrated If the contrast medium should enter the anus, it frequently may trickle up the rectum The inner opening cannot then be identified and the fistula is often erroneously considered to be rectal in point of fact more than 99 per cent are anal in origin

Fistulography with precise delineation of the anal canal increases the possi bilities of a correct diagnosis and adequate treatment This is not to say that all perianal fistulas must be radiologically examined If gentle easy probing can clarify the conditions a roentgen examination seems to be unnecessary otherwise interruption of the probing and fistulography is advisable Fistulography should always be performed in patients with relapsing fistulas

SUMMARY

A precise method of fistulography in fistulas of the rectum and anal canal has proved to be aluable asset to the clinical examination increasing the scope and accuracy of radical surgery The technique enables the relationship between the fistula and the bowel correctly to be determined

ZUSAMMENFASSUNG

Eine exakte Methode der Fisteldarstellung on Fisteln des Rektums und Analkanals erwies sich als ein brauchbarer Zuschuss bei der klinischen Untersuchung und erweitert die Indikation und Genauigkeit der radikalen Chirurgie Das Verfahren ermoglicht es die Beziehung der Fistel zum Darm ganz festzustellen

RÉSUMÉ

Une methode precise de fistulographie pour les fistules du rectum et du canal nal s'est montrée utile pour completer l examen clinique elle étend le domaine de la chirurgie radical et ameliore sa precision. Cette technique permet de determiner correctement les rapports entre la fistule et l intestin

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FROM THE DEPARTMENTS OF DIAGNOSTIC RADIOLOGY AND UROLOGY KAROLINSKA SJUKHUSET 104 01 STOCKHOLM SWEDEN

PERCUTANEOUS NEPHROPYELOSTOMY

L E ALMGÅRD and J FERNSTRÖM

Percutaneous puncture of the renal pelvis with insertion of a catheter is a method of temporary supravesical diversion rarely used (GOODWIN & CASEY 1955 BARTLEY et coll 1965 VELA NAVARRETE 1971 MOLIN & ULMSTEN 1971 SAXTON 1971 JONSSON et coll 1972) This technique makes it possible to drain the upper urinary tract in bilateral total or partial ureteric obstruction As the procedure may be carried out under local anaesthesia and furthermore is simple it may be the one of choice in cases of uremia The method is also valuable in selected cases of permanent unilateral ureteric obstruction providing a measure of saving the function of the kidney Since adequate function of nephrostomy largely depends on the size and position of the tube employed a new technique has been developed this provides satisfactory drainage which may even be made permanent if so required

Material This comprised 55 cases in 51 of which adequate function of the nephrostomy was achieved Nephrostomy was unsatisfactory in 4 in 2 of these cases the kidneys were indurated secondary to pyelonephritis, and the special instrument could not be introduced into the pelvis Hydronephrosis was absent in 2 cases and this prevented application of the method

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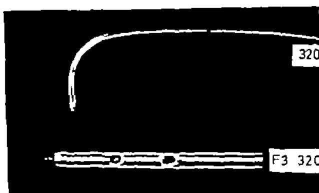


Fig 1 Instrument for percutaneous nephrostomy Prepared polythene tube 320 Tube thread on the stylet F3 +320

Satisfactory unilateral or bilateral nephrostomy was obtained in the 51 cases in 30 of which uremia was evident and caused by bilateral ureteric obstruction Thirteen cases had carcinoma of the uterus or ovary 13 carcinoma of the urinary bladder one carcinoma of the prostate one teratoma of the *testis* one case had carcinoma of the sigmoid and one case was due to surgical intervention there were 16 cases of metastases

Twenty-one cases had unilateral ureteric obstruction in 6 this was following operation and in 3 cases of carcinoma of the bladder after preoperative radiation therapy One case of carcinoma of the sigmoid with metastases 3 of ureteric stricture one of malignant lymphoma and one case of schwannoma were also observed a case of retroperitoneal fibrosis and another that had previously had right nephrectomy and had developed left ureteric calculi as well as 4 cases of carcinoma of the uterus were also included In 13 of the 55 cases bilateral nephrostomy was performed while in the remaining cases the procedure was unilateral

Technique The instrument used consists of a sharp-ended stylet 9 cm long and with a diameter of 2 2 mm and a polythene tube 8 5 cm long No 320 OD 3 5 mm (Fig 1) The latter is prepared in the following way a tube about 15 cm long is threaded onto the stylet and by pulling hard the end of the tube its diameter as well as its wall thickness will decrease The end will then become tapered to form a short thin walled snugly fitting sheath for the *top of the stylet* the tube is cut off squarely through this segment The distal part of the tube just close to the tip should be bent to an angle of about 90 after steaming Two side holes should be made in the concavity of this part, most easily done while *the stylet lies in the tube*



Fig 2 Percutaneous nephrostomy a) Unfavourable position of the tube The tip is ... the medial wall of the kidney pelvis (→) b) Correct position of the tube the tip ... the ureteropelvic junction (→)

Puncture of the kidney pelvis The puncture is made with the patient supine under monitoring with a vertical beam If the function of the kidney is adequate an intravenous injection of contrast medium may be helpful for demonstration of the renal pelvis Since most of the patients suffer from uremia this may well prove useless Localization of the kidney will then have to be obtained by meticulous screening with an image intensifier of good resolution and high gain

The external site of puncture chosen is in the axillary line at a level corresponding to the centre of the kidney the direction of the puncture should be horizontal Anaesthesia of the skin and underlying tissues is obtained with a thin needle about 9 cm long which should not be allowed to pass into the peritoneum or the intestine to avoid this complication small amounts of contrast medium should be injected intermittently with the induction of anaesthesia under the



Fig 3



Fig 4

Fig 3 Exchange of polythene tubes Th wire guides introduced nto the tube their tips lie distal to the ureteropelvic junction

Fig 4 Balloon catheter correctly sited

control of the image intensifier If necessary the site of puncture has to be chosen at a more dorsal site although this may prove uncomfortable for the patient The needle is inserted into the kidney to the probable site of the pelvis which, it should be remembered lies at the ventral aspect of the kidney a sudden flow of urine will indicate that it has been entered The pelvis is then filled with contrast medium so that its site size and shape are demonstrated The needle is then withdrawn and the direction of puncture carefully noted A small incision is made in the skin for the nephrostomy instrument The introduction of the combined stylet and tube is checked on the monitor the direction being that of the needle originally introduced The sensation transmitted to the fingertips add to the possibility of appreciating the entry of the instrument into the renal pelvis The stylet is withdrawn and a flow of urine will indicate that the tube is within the pelvis Contrast medium injected into the tube enables its exact position to be determined and if necessary adjustment of the tube to be made The tube has to be introduced until the tip reaches the pelvi ureteric junction (Fig 2 b) This manoeuvre is usually quite mple as the tube is curved although occasional

ly the tip will lie up against the medial wall of the pelvis (Fig 2 a) In such cases a wire guide with its distal tip curved in the shape of the letter J as used in cardiovascular catheterization, is introduced through the tube and gently manipulated into the ureter The tube is then passed down over the guide wire to the required position and the latter is withdrawn the tube is fixed to the skin and connected to a urinary bag by a rubber tube

Technique for permanent nephrostomy Not infrequently permanent supravesical diversion is required The tube is then replaced by a balloon catheter (Foley catheter No 12) which is more comfortable may easily be exchanged and is of a diameter that permits adequate diversion As the diameter of tube No 320 is rather small the puncture channel must be dilated before passing the larger tubes The dilatation is performed in the following way tube No 320 should lie in situ for 2 to 3 days before being replaced in turn by tube No 350 (OD 3 99 mm) and after a further 2 to 3 days by tube No 355 (OD 4 50 mm) The balloon catheter can then usually be inserted two days later if the tissues are rigid it is sometimes necessary to dilate up to a tube No 360 (OD 4 82 mm) before the balloon catheter can be introduced The tubes are exchanged by means of two wire guides (No 160 diameter 0 90 mm and 205 diameter 1 20 mm) usually used for catheterization of arteries Both guides are introduced into the tube until the tips enter the upper part of the ureter The tube is withdrawn and the next tube in number is pushed on to the guides until it reaches the required position (Fig 3) Tubes No 350 355 and 360 are prepared in a similar way to that described for No 320 When the balloon catheter is introduced only the 205 wire guide with a small hole that fits the wire cut out on the top of the catheter is employed (Fig 4) Anaesthesia is not required on exchanging tubes or catheters The balloon catheter is replaced once every month this can easily be done without assistance from the roentgen department

Results

Nephrostomy of 66 kidneys was performed with good results Puncture of the pelvis with the instrument described was usually successful at the first attempt but up to three attempts of punctures had occasionally to be made The tubes or catheters were removed in 16 cases within two months 3 of these cases were treated early in the series as the position of the tube became unsatisfactory after 2 to 3 weeks and surgical nephropyelostomy had to be performed The other 35 cases needed permanent nephrostomy and some have had catheters for up to three years

The flow of urine ceased after a week in one case with a permanent nephrostomy. On control the tip of the catheter proved to lie in the ascending colon; the catheter was removed and no further complications occurred. No other complications occurred in the 55 cases treated. Bleeding from the pelvis through the tube was not infrequently observed during the first few minutes following puncture but ceased spontaneously in spite of the fact that severe haemorrhage is a frequent sequela following operative nephrostomy. Nephro-angiography was performed in 18 cases at times varying from 1 hour up to 7 days after the puncture; no evidence of arterial injury was observed. It is of interest that 11 of these cases that were pyrexial before this procedure became afebrile following it.

Discussion

BARTLEY et coll. (1965), JONSSON et coll. (1972), MOLIN & ULMSTEN (1971) and SAXTON (1971) have described percutaneous nephropyelostomy to provide for drainage of the renal pelvis for a short time with small attendant risks of complication. Permanent supravesical diversion with this technique is usually not feasible since the catheter is prone either to slip out or be closed by obstruction.

The method presented enables the use of balloon catheters in cases requiring permanent supravesical diversion. This simplifies exchange of catheters and furthermore the catheters retain their positions. The balloon catheters also have a wider diameter than those employed by the above mentioned authors so that blood clots are less apt to cause obstruction. The particular value of the method lies in the positioning of the catheter which allows the patient to rest on his back without interference with the drainage. Percutaneous nephrostomy would thus appear to become the method of choice for both temporary and permanent supravesical diversion. The risk is small and operative nephrostomy should be resorted to only if the new method be unsuccessful.

SUMMARY

A technique of percutaneous nephrostomy for permanent supravesical drainage with balloon catheters is described. The lateral insertion enables the patient to rest on the back comfortably without interfering with the drainage. Operative nephrostomy should be resorted to only in a few selected cases.

ZUSAMMENFASSUNG

Eine Technik für die perkutane Nephrostomie, die es ermöglicht, oberhalb der Blase eine Drainage mittels eines Ballonkatheters vorzunehmen, wird angegeben. Da der Eingriff an der Seite vorgenommen wird, kann der Patient bequem auf dem Rücken liegen ohne den

Katheterabfluss zu stören Demgemäss sollte eine wirklich operative Nephrostomie nur selten nötig sein

RÉSUMÉ

Description d une technique de nephrostomie percutanée a ec des sondes à ballonnet pour drainage sus vesical permanent L insertion latérale de la sond permet au patient un decubitus dorsal confortable qui ne gene pas le drainage La nephrostomi operatoire devrait tre reservee à quelques cas selectionnés

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EFFICIENCY OF INTENSIFYING SCREENS

SVEN REICHMANN

The predominant screen phosphor of today is calcium tungstate and has been so for many decades New systems are however now emerging BUCHANAN et coll (1972) have stated that screens with rare earth oxysulphide phosphors have certain advantages Other phosphors consist of barium lead sulphate and certain similar compounds such as barium strontium sulphate Screens of these substances are now marketed by Kodak Inc for clinical routine radiography under the label of Kodak X-omatic Barium lead sulphate is not new MATTSSON having tested it as early as 1955 Clinical comparison between the X-omatic system and a comparable routine system including calcium tungstate screens and ordinary RP film has now been undertaken to find out whether any difference in image quality could be detected when the two systems were similarly exposed

Material and Methods The tests were carried out during ordinary ro tine radiography Two roentgenograms were obtained for each patie h centering and field size being used for every pair The expos mostly also identical When this was not possible owing to sensitivity the tube potential was kept constant In a few case ar

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a b

Fig. 1. Tomograms through the ear of a skull embedded in plastic. Registration with a) tungstate screens and b) X-omatic screens. The quantum mottle appears as coarse granularity, more evident in (a) than in (b); detail is better in (b).

tomograms obtained at short exposure times—it was deemed of interest to determine whether the X-omatic system might produce films at lower tube potentials than the standard system. These cases will be specially considered.

The pairs of roentgenograms were obtained in the following types of examinations: skeleton of the trunk and extremities, the lungs and colon, as well as in urography, intravenous cholegraphy and various types of tomography including ear tomography of a skull embedded in plastic. The absence of suitable screens prevented the X-omatic system being tested in angiography. Considerable similarities however exist between angiography of the abdomen and intravenous cholegraphy so that certain assumptions may be made.

The material consisted of 99 pairs of roentgenograms obtained from adults of all ages; children were not included.

The X-omatic system contains two types of screen, fine (for low sensitivity) and regular (for high sensitivity) and two sorts of film, general (for low sensitivity) and high (for high sensitivity). The sensitivity factor between the two types of screen is 6 to 8, the corresponding value for the films being 2.0. In practice three different combinations are used, the combination of fine screens with high sensitivity film not being recommended by the manufacturer. The fine screens together with a film of ordinary sensitivity are intended to replace the medical non-screen film. When this latter film was used as a routine it was compared with the screen film combination just mentioned.



b

Fig. 2. Tomograms of common bile duct. a) Tungstate screens compared with b) X-omatic screens: better recording of the low contrast object in (b).) A secondary increase in contrast in (a) has not led to improvement.

The reference system consisted of Siemens Saphir screens containing calcium tungstate and Agfa/Gevaert Curix RP film. This system had the same sensitivity as the regular X-omatic screens combined with the general film. The medical non-screen film was the Agfa/Gevaert Osray M intended for roll machine development. This might suggest that the investigation was primarily a comparison between Kodak screens and films on the one hand, and Siemens screens and Agfa/Gevaert films on the other. Every reason may however be given that the choice of manufacturer has but a marginal influence. Standard screens and films made by Kodak should consequently not be expected to differ significantly from the reference system employed.

Results

These should be prefaced by a consideration of what happens to a screen-film combination when exposed to roentgen rays without any object being inserted into the roentgen beam. Theoretically completely homogeneous density of the film should be obtained after development; this however does not occur but is replaced by two types of inhomogeneity. The first is due to the graininess



b

Fig 1 Tomograms through the ear of a skull embedded in plastic Registration (with) tungstate screens and b) X-omatic screens The quantum mottle appears as coarse granularity more evident in ( ) than in (b) detail is better in (b)

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Fig 4 Part of the sigmoid colon filled with barium sulphate. No significant difference in image quality between a) tungstate screens and b) Xomatic screens

constantly observed on comparison of these two screen film combinations that the quantum mottle was more easily visible in the calcium tungstate alternative which also had a lower detail resolution

The visibility of the quantum mottle was about the same in the high sensitivity Xomatic combination as in the calcium tungstate reference system Since the sensitivity could thus be increased by 100 per cent without any increase in quantum mottle visibility it appeared especially worthwhile to test it in intravenous cholegraphy In this type of examination the author always takes linear tomograms to keep the exposure time low so as to avoid movement unsharpness (REICHMANN 1978) The tube potential must however also be kept down and a compromise is usually necessary for this reason the voltage often becomes higher than desirable This conflict between exposure time and low potential is the same as is so often encountered in angiography of the abdomen The reference system was consequently compared with the high sensitivity Xomatic system The potential in the case in Fig 2 was thus reduced from 75 to 69 kV and obviously produced a better recording The disturbing mottle was the same in the two alternatives but since the image itself had a higher contrast with the X-omatic system an increase in low contrast detail was obtained When the quality of a screen film system is discussed its rendering of contrast is often stressed [illegible] is important However if the contrast be increased by means of a har[illegible] [illegible]king film, then the visibility of the quantum mottle together with this [illegible] image will increase The tomogram in Fig 2 was copied with higher [illegible] Fig 2 c) to demonstrate that the quantum mottle rather than the co[illegible]ndering of this system is the limiting factor



b

Fig 5 Bone tructure in roentgenograms obtained at 130 kV Mottle masks fine detail with a) tungstate screens but b) not with X omatic screens

With a term borrowed from the technology of sound amplification quantum mottle is denoted as a kind of disturbing noise while the image is called the signal It is evident that the signals should as much as possible be stronger than the noise When Figs 2 a and c are compared, it is apparent that the signal/noise ratio has not been altered the visibility of both has increased equally To pursue the analogy with a sound amplifier the contrast function of the screen film system may be compared with the loudness control An increase in film contrast resembles an increase in sound volume Both signals and noise will be more easily discernible but it will not become easier to separate them The X-omatic system as used in the example (Fig 2) resulted in a constant noise but an improved signal The signals thus became easier to differentiate from the noise more detail without disturbance by the quantum mottle was apparent

The signal/noise ratio may be made increasingly favourable by means of increased signal intensity as was described in the foregoing This increase is obtained by means of a lowering of the tube potential Signal intensity may however be kept constant and the noise lowered This is the alternative already illustrated in Fig 1 This technique proved to be preferable in two cases (a) when very fine detail was to be recorded (cf Fig 1) and (b) when it was undesirable to lower the voltage The latter is encountered in radiography of the lung and led to the reference system being compared with the medium sensitivity X-omatic system in such examinations A surprising increase in detailed rendering of the pulmonary structures was obtained (Fig 5)



b

Fig 6 Distal end of fra tured radius Recording made with) medical non screen film and b) th lowest sensiti ity X omatic alternative w th which detail of the skeleton is somew hat better recorded

The object in some types of examination regularly gives rise to relatively favourable signal/noise ratios owing to high absorption capacity This obtains in gastro intestinal examinations with barium sulphate as contrast medium It also occurs in skeletal radiography of subjects not displaying osteoporosis if a suitably low tube potential be used In these categories the reference system was compared only with the medium sensitivity X-omatic system simply because the automatic exposure procedure allowed no other type of comparison The two types of roentgenogram differed in background mottle but since the signals were well above the noise level the difference in image quality was not considered to be diagnostically important (Fig 4)

The examinations of the colon were performed at 130 kV The image pairs revealed a clear difference in the recording of the skeleton so that the low noise system in fact afforded an acceptable depiction of the bone structure in spite of the high tube potential The background mottle in the reference images was so intense as to mask these structures (Fig 5) The recording of the skeleton was thus not altered by a low tube potential but it became dependent on the noise level when the potential was increased and the signal intensity corre spondingly decreased

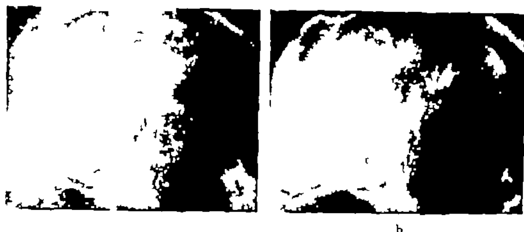


Fig. Bone structure in roentgenograms obtained at 130 kV. Mottle masks fine detail with a) tungstate screens but b) not with X-omatic screens.

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The signal/noise ratio may be made increasingly favourable by means of increased signal intensity as was described in the foregoing. This increase is obtained by means of a lowering of the tube potential. Signal intensity may however be kept constant and the noise lowered. This is the alternative already illustrated in Fig. 1. This technique proved to be preferable in two cases: (a) when very fine detail was to be recorded (cf. Fig. 1) and (b) when it was undesirable to lower the voltage. The latter is encountered in radiography of the lung and led to the reference system being compared with the medium sensitivity X-omatic system in such examinations. A surprising increase in detailed rendering of the pulmonary structures was obtained (Fig. 3).

Discussion

The X-omatic system proved to have less visible quantum mottle in a sensitivity identical with that of the reference system Paradoxically it may happen that screen film combinations of a relatively low quality may give rise to less visibility of the quantum mottle than a high quality combination This is due to a spreading out of the light within the poorer screens so that quantum mottle is also depicted with such unsharpness as to become indistinct in spite of its presence (Rossman 1964) At the same time the screens with a low quantum mottle invariably render poorer detail and faint signals Since the X-omatic system gave an improved recording of these kinds of signals and less visible quantum mottle there appeared to be justification for assuming that true lowering of the quantum mottle did occur

This investigation seems to have demonstrated that quantum mottle is an important factor in limiting the information capacity of clinical roentgenograms It would also appear that not all types of examination suffer equally from the influence of noise In principle the reference and X-omatic systems produced similar recordings of signals which were well above the noise level provided the detail was not too fine Since the noise level of the reference system may in these cases be accepted, a dose reduction may be obtained with the high sensitivity X-omatic alternative both patients and tubes will benefit An attempt has been made in the Table to suggest which types of X-omatic films and screens may be preferable in different examinations

A comparison between the reference system and the X-omatic alternative of identical sensitivity suggests that the image of the latter is built up of more photons even though the dose i e the total number of photons striking the front screen is unaltered This should be regarded as a true improvement in efficiency However the term efficiency is used in a somewhat confusing way when applied to intensifying screens The common means of expressing the efficiency of an intensifying screen is by the roentgen to-light conversion factor The roentgen energy absorbed is measured and compared with the output of light energy A high conversion factor is considered favourable it is present when large amounts of light are obtained from small amounts of roentgen photons Another not so clearly defined way of expressing the same thing is by means of the intensification factor the roentgen dose necessary for blackening the film without screens is compared with the dose required when screens are used Since the characteristic curve of the film is grossly changed by screens the intensification factor should be abandoned altogether The conversion factor remains unaltered however from a physical point of view still its validity for the measurement of screen quality must be questioned

BUCHANAN et coll recently presented two new screen phosphors with considerably higher conversion factors than calcium tungstate to a lesser degree these phosphors also have a higher capacity to absorb roentgen photons The gain in conversion factor was stressed by the authors, but perhaps not rightly so however since it is the absorptive capacity and not the conversion factor that determines the number of photons that will participate in forming the final image Even if its conversion *factor* be low a new type of screen will represent true progress if only the absorptive capacity be high the low conversion factor *can be balanced by a film of higher sensitivity*

SUMMARY

Quality in routine radiography is often limited by quantum mottle This can be reduced without an increase in dose if the film or screen film system takes up a larger fraction of *the radiation that passes through the object The absorptive capacity is thus a good measure* of the efficiency of a recording medium and this has been demonstrated by a comparison of two screen film systems

ZUSAMMENFASSUNG

Die Qualitat von Routinerontgenbildern ist haufig durch die Quantenfleckigkeit begrenzt Diese kann ohne einen Anstieg der Dosis vermindert werden wenn der Film oder das Schirmbildsystem einen grosseren Teil der Strahlung die das Objekt passiert aufnimmt Die absorptive Kapazitat ist daher ein gutes Mass der Effektivitat eines registrierenden Mediums Dies wurde bei einem Vergleich von zwei Schirmbildsystemen gezeigt

RÉSUMÉ

La qualité des films dans le travail radiologique habituel est souvent limitée par le grain quantique Celui-ci peut être réduit sans augmentation de la dose si le film ou le système écrans film enregistre une plus grande fraction du rayonnement qui passe à travers l'objet La capacité d'absorption est ainsi une bonne façon de mesurer l'efficacité d'un moyen d'enregistrement et ceci a été démontré par la comparaison de deux systèmes écrans film

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A MATHEMATICAL MODEL OF NARROW BEAM ROTATION METHODS

ULF WELANDER

The first suggestions that a rotating narrow beam might be used to obtain special radiologic projections were put forward by VALLEBONA (1930) and HECKMANN (1939). A method for exposing panoramic images of the jaws, using a rotating beam, was developed from the works presented by PAATERO (1949, 1954) and is today in wide use in odontologic roentgen examinations.

PAATERO's method (pantomography) was presented as a modified form of tomography adapted for application to a curved layer, and the mathematical analyses of the method presented up to now have been based on this premise (HUDSON et coll. 1957, DUHAMEL 1954, 1957, SOILA 1961, TAMMISALO 1964, TAMMISALO & NIEMINEN 1964). DUHAMEL (1957) maintained that the image is composed of a series of tomograms whose widths correspond to the width of the beam.

The principle underlying the methods based on a rotating narrow beam differs fundamentally from that of true tomography, however. WELANDER & NYSTROM (1971) have demonstrated empirically that the rotating slit method creates an imaginary focus at the rotation centre of the beam: this rotation focus constitutes the source of the rays in a central projection. The blurring and

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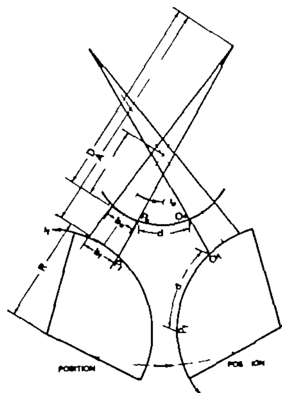


Fig. 1. The principle for exposure of curved object by means of rotating narrow beam and a moving film. The figure illustrates two positions between which continuous movement takes place during the depicting of the distance d in the object.

magnification of the image in this projection is controlled by giving the film a suitable velocity in relation to the object and the beam during the exposure. The image on the film may be defined as an orthoradiographic representation of a curved object.

Using the theory concerning the principle of rotating slit method described by WELANDER & NYSTRÖM a mathematical model of such method, which is valid for the rotation plane, the horizontal plane, is presented in this paper. The conditions in the vertical plane have been excluded.

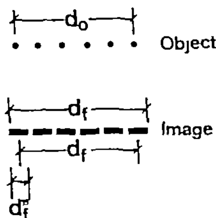
Mathematical model

Definitions (See Figs. 1 and 2.)

d = distance in the object

d_f = length of the distance d projected on the film

d_t = true length of the distance d projected on the film when the characteristic blurring is eliminated



$U_w = |d_f''| \qquad d_f = d_f + U_w$

Fig 2 Schematic representation of the relation between the length of distance in the object (d) projected on the film (d_f) and the true length of the distance in the film (d_f) d f the length f point in the object projected on the film

M = magnification factor $\frac{d_f}{d_o}$

d f = length of a point in the object projected on the film direction of *projection movement is shown by positive or negative sign*

U_w = characteristic unsharpness of rotating narrow beam methods d f

r = radius of the object

R = radius of the film

= angular velocity of the beam

ω_f = angular velocity of the film

b = width of the beam in the object

b_f = width of the beam on the film

D = distance tube target to object

A = distance target to film

t = exposure time

The symbols and definitions agree wherever applicable with the norms recommended by the ICRU (1962)

Deduction

Fig 1 shows the principle for exposure of an image of a curved object by means of a rotating narrow beam and a moving film the target is assumed to be of negligible size

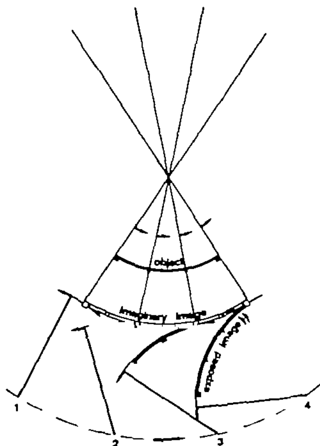


Fig. 3. The rotation centre as source of the rays (rotation focus) produces an imaginary image whose size in relation to the object is directly proportional to the rotation focus—film and rotation focus—object distance. The imaginary image is exposed successively on the moving film and its length dimension can be altered.

From the moment when one of the marginal rays of the beam enters the distance d_0 in the object at the point P (position 1) until the other marginal ray leaves the distance d_0 at the point Q (position 2), the central ray travels the distance

$$d_0 + b_0$$

During the exposure time t the central ray travels in relation to the object the distance

$$r\omega_0 t$$

Thus

$$d_0 + b_0 = r\omega_0 t$$

$$t = \frac{d_0 + b_0}{r\omega_0} \qquad (1)$$

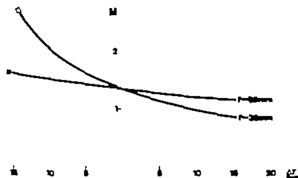


Fig 4 The magnification factor M as function of an increment Δ to the radius of the object The indicated functions are valid for the anterior rotation centre and the first part of the lateral rotation centre in the Orthopantomograph 3 R = 165 mm = 28 mm $r_1 = 89$ mm $\frac{\omega_f}{\omega} = 0.228$ and $\frac{\omega_f}{\omega} = 0.729$ respectively

In position 1 the object point P is depicted on the film in the point P_f and in position 2 the object point Q_o is depicted in the point Q_f. The distance d is depicted successively on the film as the distance d_f. The total distance travelled by the central ray in relation to the film from the moment when one of the marginal rays is in the point P_f until the other marginal ray is in the point Q_f is

$$d_f + b_f$$

During the exposure time t, the film travels, in relation to the central ray the distance

$$R\omega_f t$$

Thus

$$d_f + b_f = R\omega_f t$$

$$t = \frac{d_f + b_f}{R\omega_f} \tag{2}$$

The exposure time t is common to equations (1) and (2). It is thus true that

$$\frac{d_f + b_f}{R\omega_f} = \frac{d_o + b_o}{r\omega_o}$$

Removing d_f we get

$$d_f = \frac{R\omega_f}{r\omega_o}\left(d_o + b_o\right) - b_f \tag{3}$$

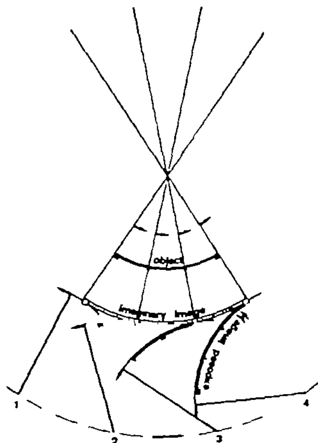


Fig 3 The rota centre source of the ra (rotation focus produces an imaginary image who size relative to the object is directly proportional to the rotation focus—film and rotation focus—object distance The imaginary image is exposed piece by piece on the moving film and its length dimension can be altered

From the moment when one of the marginal rays of the beam enters the distance d in the object at the point P position 1 until the other marginal ray leaves the distance d at the point Q position 2 the central ray tra the distance

$$d + b_o$$

During the exposure time t the central ray travels in relation to the object the distance

$$r\omega t$$

Thus,

$$d + b_o = r\omega t$$

$$t = \frac{d_o + b_o}{r\omega_o} \quad (1)$$

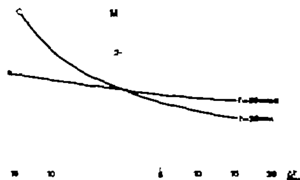


Fig. 4. The magnification factor M as function of an increment Δ to the radius of the object. The indicated functions are valid for the anterior rotation centre and the first part of the lateral rotation centre in the Orthopantomograph 3. R = 165 mm, r_1 = 78 mm, = 69 mm, $\frac{\omega_f}{\omega_o}$ = 0.228 and $\frac{\omega_f}{\omega_o}$ = 0.729 respectively.

In position 1 the object point P is depicted on the film in the point P_f and in position 2 the object point Q_o is depicted in the point Q_f. The distance d_o is depicted successively on the film as the distance d_f. The total distance travelled by the central ray in relation to the film from the moment when one of the marginal rays is in the point P_f until the other marginal ray is in the point Q_f is

$$d_f + b_f$$

During the exposure time t, the film travels in relation to the central ray the distance

$$R\omega_f t$$

Thus

$$d_f + b_f = R\omega_f t$$

$$t = \frac{d_f + b_f}{R\omega_f} \quad (2)$$

The exposure time t is common to equations (1) and (2). It is thus true that

$$\frac{d_f + b_f}{R\omega_f} = \frac{d_o + b_o}{r\omega_o}$$

Removing d_f we get

$$d_f = \frac{R\omega_f}{r\omega_o}\left(d_o + b_o\right) - b_f \quad (3)$$

The relation between the width of the beam in the object and on the film is directly proportional to the relation between the distances target—object and target—film

$$\frac{b_o}{b_f} = \frac{D}{A} \quad b_o = \frac{b_f D}{A}$$

With the film and object radii and beam widths used in practical systems for exposing images by narrow beam rotation the curvature of the object and of the film in the beam is negligible (TAMMISALO & NIEMINEN 1964). Using this approximation b_o in equation (3) may be expressed as a function of b_f. In the following b_f is used to symbolize the width of the beam on the film to denote that the approximation has been performed. We then get the following expression

$$d_f = \frac{R\omega_f}{r\omega_o}\left(d_o + \frac{b_f D}{A}\right) - b \tag{4}$$

Application

The geometrical proportions of the image. In theory an image without blurring can be produced with the narrow beam rotation methods if the beam is of negligible width. The true length in the image of an object will thus be obtained from (4) if $b_f \rightarrow 0$

$$d = \frac{R\omega_f d_o}{r\omega_o}$$

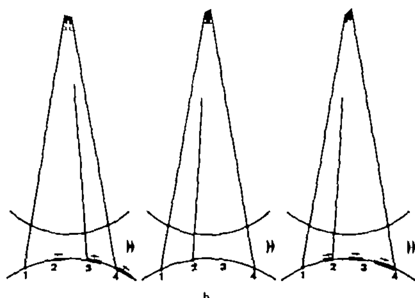
From this expression it appears that the true length of the image is directly proportional to the ratio of the velocity of the film to that of the beam but is independent of the target—object and target—film distances. This means that the projection is determined by the factors that are parameters in a central projection which has the rotation centre as source of the rays, the rotation focus (Fig. 3).

At different distances Δr from the radius of the object r the length of the image will be

$$d = \frac{R\omega_f d_o}{(r+\Delta r)\omega_o} \tag{5}$$

The magnification expressed as the ratio of the true length of the image to the length of the object is

$$M = \frac{d_f}{d_o} = \frac{R\omega_f}{(r+\Delta r)\omega_o} \tag{6}$$



b

Fig 5 A point exposed in four positions while passing narrow beam Both the object and the film move from left to right in the figure A point in the object will be sharply depicted when the projection of the point on the film is stationary in relation to the film (b) this applies in divergent beam when the film has somewhat higher velocity than the object When the film moves t higher velocity than the projection of the point on the film the direction of the point's projection is negative (rrows) When the film moves t lower velocity than the projection of the point on the film the direction of the point projection is positive (arrow)

$M = f(\triangle r)$ is exemplified in Fig 4 with the values valid for the anterior rotation centre and the lateral rotation centre in the Orthopantomograph 3 For the continuous transition between the two rotation centres M is variable continually in the interval between the functions

The characteristic blurring of the image Unsharpness has been defined as the point spread function which includes the energy distribution in the image plane (ROSSMANN 1969) It seems sufficient for the present purpose however simply to regard the blurring occurring with the rotating narrow beam methods as the length of the point spread function i e the length of a point's projection on the film This will be obtained from (4) when $d \rightarrow 0$

$$d = \frac{R\omega_r b_r D}{r\omega_o A} - b_r \tag{7}$$

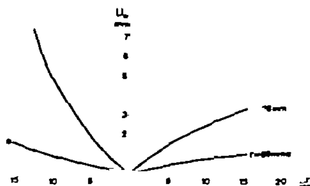


Fig. 6. The unsharpness U_w as a function of an increment Δr to the radius of the object r. The functions indicated are valid for the anterior rotation centre and the first part of the lateral rotation centre in the Orthopantomograph 3 with a beam width of 10 mm. $R = 165$ mm, $D_1 = 340$ mm, $D_2 = 345$ mm, $A = 460$ mm, $= 78$ mm, $= 89$ mm.

According to this expression, the length of a point's projection is directly proportional to the width of the beam and is dependent on the distances target—film and target—object. These factors are parameters in a central projection with the tube target as the focus and they thus determine the unsharpness of the image. However, the total length of a point's projection on the film is also affected by the relation between the film velocity and the beam velocity in the object (Fig. 5).

The length of a point's projection is obtained from equation (7). Outside a sharply depicted plane the projection of a point in the object will move in relation to the film while the beam passes the object. The direction of this movement is different on each side of the sharply depicted plane. The direction of the point's projection is indicated by a positive or a negative value for d_f when the equation is solved. The blurring however is not dependent on the direction of the point's projection, $U_w = |d_f|$. Thus at different distances Δr from the radius of the object, r

$$U_w = \left| \frac{R\omega_f b\,(D+\Delta r)}{(r+\Delta r)\omega_0 A} - b_t \right| \tag{8}$$

With the values valid for the anterior and lateral rotation centres in the Orthopantomograph 3 the functions for $b_t = 10$ mm (Fig. 6) are obtained from this expression. For the continuous transition between the rotation centres U_w varies continually in the interval between the functions.

The resultant image. Equation (4) is of universal application and gives the characteristics of the exposed image when the different factors are varied independently of one another. If satisfactory sharpness of the image is to be obtained by narrow beam rotation the characteristic blurring must be eliminated

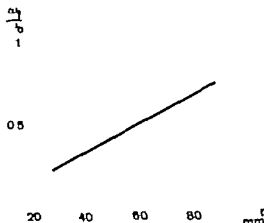


Fig 7 $\frac{\omega_f}{\omega_b}$ as function of the radius of the object R = 165 mm D = 340 mm A = 460 mm and 28 < < 89 mm The lines constitute an approximation of the transition from the anterior rotation centre to the beginning of the lateral rotation centre in the Orthopantomograph 3

in part of the object Equation (7) provides the relation between the velocities of the film and of the beam that must apply in order to make U = 0 We get this from

$$\frac{R\omega_f b_r D}{r\omega_b A} = b_r$$

$$\frac{\omega_f}{\omega_b} = \frac{rA}{RD} \tag{9}$$

$\frac{\omega_f}{\omega_b} = f(r)$ is illustrated in Fig 7

From equation (9) it is apparent that the relation between the film velocity $R\omega_f$ and the beam velocity in the object $r\omega_b$ must be proportional to the relation between the target film and target object distances if the unsharpness is to be eliminated in part of the object In consequence the geometrical proportions will be affected and the image will be magnified (cf equations (6) and (8) and the functions in Figs 4 6)

Thus an image produced by means of a rotating narrow beam is composed of two central projections one of which has the rotation centre (rotation focus) and the other the tube target as the focus The simultaneous effect of the two projections on the nature of the image may be analysed with the aid of equation (4) which may be used as a mathematical model of rotating narrow beam methods

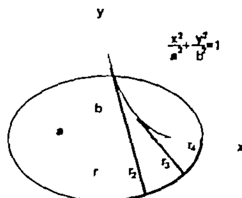


Fig. 8. Elliptic movement. The rotation focus moves along the evolute of the ellipse. The effective projection radius for each part of the movement along the ellipse is the length of the perpendicular to the point where it is tangent to the evolute.

In summary, the mathematical model may be written

$$d_f = d + U_w = \frac{R\omega_r d_o}{r\omega_o} + \left| \frac{R\omega_r b_r D}{r\omega_o A} - b \right|$$

The equation is valid for a circular movement but can be applied in other movements if r is substituted by an adequate function. For an elliptical movement the following is valid

$$r(x) = \frac{(a^4 + x^2(b^2 - a^2))^{3/2}}{a^4 b}$$

where r is increasing or decreasing in the interval where $-a \leqslant x \leqslant a$ (Fig. 8).

Discussion

The systems in which a rotating narrow beam is used (VALLEBONA 1930, HECKMANN 1939, PAATERO 1949, 1954, VUORINEN 1957) have been classified as tomographic methods (ICRU 1962), but these systems do not coincide with the definitions of tomography (LINDHOLM 1960); they should instead be described as methods for producing orthoradiographic images of curved objects (WELANDER & NYSTRÖM 1971).

As a result of unclear definitions, the mathematical expressions derived for these rotation methods on the presupposition that a defined tomographic layer is present in the object plane have been incompletely, and to a certain extent incorrectly interpreted. In the calculation of the geometrical proportions of the image, the distance in the image between two points in the object has thus been summated—or subtracted—with the projection lengths of the points (TAMMI-

SALO 1964) with the result that a calculated distance has been affected by the magnitude of the unsharpness. The length of a point's projection on the film has been calculated by TAMMISALO & NIEMINEN (1964). Their result is the same as the function obtained from equation (7), but this does not indicate that there is a defined tomographic layer in the object plane. The derivation of the mathematical expressions of TAMMISALO and TAMMISALO & NIEMINEN was based on the supposition that the unsharpness is eliminated in the object plane when the relation between the film and beam velocities is directly proportional to the distances target—film and target—object. This presupposition is correct, but it leads to an incomplete mathematical expression. Their formula for the calculation of the length of a point's projection on the film is cancelled when a variable factor Δr is absent, and the other factors therefore cannot be varied unconditionally.

The functional principle of the rotating slit methods can only be fully understood if the characteristics of the image with respect to length, dimension and blurring, and the image forming factors are given clear cut definitions. In the derivation and application of the mathematical model presented in this report the rotating slit systems were strictly defined.

The mathematical model demonstrates that an image produced with a rotating narrow beam is composed of two central projections acting simultaneously. The beam from the imaginary source, rotation centre (rotation focus), determines the geometrical proportions of the image and is the essential image forming beam while the beam from the tube target produces the blurring. The two projections are influenced in several ways by the same factors, but are independent of each other, as is evident from the fact that the mathematical model constitutes the sum of two separate expressions, one for each projection.

When a point is projected in different directions on both sides of a sharply depicted part of the object, the blurring occurring with rotating narrow beam methods will have a superficial resemblance to tomographic blurring but does not tally with the definitions of the latter type (EDHOLM 1960). The unsharpness, furthermore, does not have the same effect or function as in tomography. In the rotating narrow beam methods it is a pseudotomographic side effect arising from the fact that a central projection of the curved object cannot, for practical technical reasons, be achieved with negligible width of the beam. The blurring that occurs with narrow beam rotation methods should be regarded as a geometrically determined motion blur, which is typical of these methods. In the special case in which there is no relative motion between object and film, $R_h = r\omega$, and in which the curvature of film and object is negligible, the characteristic blurring is identical with the unsharpness seen in the orthoradiographic methods of HECKMANN (1939) and MALVOISIN (1951).

SUMMARY

A mathematical model of the rotating narrow beam methods has been derived and applied in order to describe the principle for the functioning of the methods It may be pplied in general in the search for the optimal conditions for narrow beam rotation in comparisons between different systems based on such rotation and in calculations of the geometrical proportions and bl rring in the exposed image

ZUSAMMENFASSUNG

Es ist ein mathematisches Modell fur die Methoden mit einem rotierenden schmalen Strahlengang hergeleitet und ngewandt worden um das Prinzip der Funktion dieser Methode zu beschreiben Es kann generell verwendet werden um die optimalen Bedingungen fur die schmal Strahlengangrotation festzustellen erschiedene Systeme die uf einer der artigen Rotation aufbauen miteinander zu ergleichen und um die geometrischen Propor tionen und Unscharf des exponierten Bildes zu berechnen

RÉSUMÉ

L auteur etabli un modele mathem tique des méthodes utilisant un faisceau etroit tournant et a appliq é ce modèle à la description du principe de fonctionnement d es methodes Ce modèle peut etre pplique en general pour rechercher les conditions optimales de rotation du faisceau etroit pour comparer differents systèmes bases sur ett rotation et pour calculer les proportions geometriques et l flou de l image exposee

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RADIOLOGIC EXAMINATION OF THE SMALL INTESTINE BY DUODENAL INTUBATION

J L Sellink

Although the roentgen examination of the small intestine has been a common procedure for the past 70 years the results unfortunately still give little cause for satisfaction While knowledge of the diseases of the small bowel has increased considerably the radiologic examination has hardly changed As a result of diverging views a number of techniques have been developed these differ to such an extent that the average transit time may vary from 1 to 6 hours This is perhaps not surprising in view of the fact that the time is dependent upon factors such as the amount caloric and osmotic values as well as the temperature and method of administration of the contrast medium In addition the number of media on the market continues to grow although even today none approaches the ideal Standardization of the method of examination and the contrast medium has been suggested

Braeckman (1947) analysed the influence of particle size and the addition of hydrophilic colloids on the rate of sedimentation of a barium sulphate suspension and plotted the results against time (Fig 1) Zimmer (1948) was one of the first to investigate flocculation in vitro by adding substances from the digestive tract, such as mucin fatty acids and gastric juice, that enhance the phenomenon The percentage of flocculation was also recorded against time (Fig 2) The curves of Braeckman and Zimmer proved to be practically identical and in

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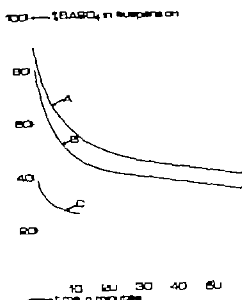


Fig 1 Difference in rate of sedimentation (after Braxex) (A) $BaSO_4$ + 0 01 Na citr + 7 5 gum rabic B) $BaSO_4$ + 7 5 gum arabic C) BaSO + 0 01 % Na citr

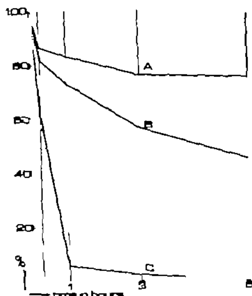


Fig 2 Sedimentation curves of Zdoch (1949) Difference between A) Alubar Wander B) high quality brand and C) barium suspension without additives

dicated that these media quickly settle out of suspension Sedimentation is of course of little importance in the lumen of the continuously contracting small bowel there it is only a matter of chemical flocculation Flocculation of a barium suspension and its disintegration into increasingly large clumps is a physicochemical process that increases with the transit time Clumping is further enhanced by the physiologic withdrawal of water from the suspension in the distal part of the ileum and in the colon Unfavourable conditions as for instance in diseases of malabsorption and inflammation will cause the most rapid changes in the contrast medium Once flocculation or segmentation has developed anatomically true representation of the intestinal lumen is an illusion (Fig 3) It is therefore most necessary to increase the rate of transit so that the caecum is reached as quickly as possible the roentgenogram should be obtained only while the barium is still in suspension

This view was confirmed by clinical experience serious cases sometimes allow only 10 or 15 minutes for mucosal patterns (Fig 4) In addition it is hardly surprising that drugs that accelerate transit such as Sorbitol (Porcher & Caroli 1957) and Metoclopramide (James & Hume 1968) produced a definite im



a b

Fig 3 J junal loop in case of liposarcoma) Homogeneous contrast column The narro spaces between the coarse mucosal folds are filled with medium and clearly uble b) Disintegration of the barium suspension a few moments later Splotchy appearanc of contra t colum No mucosal folds uble

provement in the mucosal patterns especially in the ileum where the detrimental effect of removal of water from the suspension then also decreased

The acceleration in the passage obtained by WEINTRAUB & WILLIAMS (1949) who administered 2 × 200 ml ice-cold normal saline subsequent to the examination of the stomach had of course an adverse effect on the quality of the mucosal patterns It is also understandable that larger amounts of medium administered in the shortest possible time as long advocated by MARSHAK & LINDNER (1970) offer the best buffer action against the damaging effect of gastric and intestinal

b

Fig 4) Con entional gastrointestinal transit examination in malabsorption syndrome of unknown nature b) Same examination a week later with the author technique Improved filling of (distended) intestinal loops without signs of d sintegration of the contrast medium

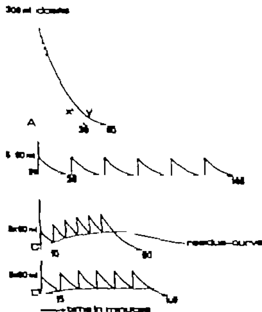


Fig 5 A) Ga tric emptying curv Y (——) sitting or standing position (— —) righ lateral position B) Ideal fractionation Rate of supply equals rate of emptying C) D) Fractionation Rate of supply is greater than rate of emptying increasing residue in the stomach.





b





d

Fig 6) b) Normal mucosal pattern) d) Disintegration of the contrast medium th same intestinal loop Flattening and pparent coarsening of the mucosal folds The structure of the medium has become granular (clearly visible in the original film)



Fig 7



Fig 8

Fig 7 Small intestine flushed with water practically all the medium lies in the colon

Fig 8 Double contrast examination of the colon immediately after that of the small bowel Air injected through duodenal tube

juices Possible flocculation is thus moved to a later period in the examination as well as to a more distal location The frequent administration of small amounts of medium as described by PANSDORF (1937) and now used by LASSRICH among others has on the other hand an unfavourable effect on the suspension and therefore on the quality of the film The stomach then empties much more slowly (Fig 5) so that the medium remains in contact with larger quantities of gastric and intestinal juices for longer periods

It thus appeared that the administration of larger quantities (500 to 600 ml) of a stable barium suspension the stimulation of gastric emptying by drugs that enhance peristalsis and positioning of the patient on the right side must provide a sufficient guarantee for good mucosal patterns under all circumstances in the event of serious malabsorption and inflammatory diseases Numerous illustrations even in up-to-date textbooks (MARSHAK & LINDNER ROBBINS 1969) suggest however that this conclusion may be erroneous Many of the diseases of the small intestine accompanied by malabsorption are associated with marked disintegration of the medium in the ileum or even the jejunum this has led to totally unrealistic mucosal coarsening and false patterns and as a result incorrect interpretation Fig 6 indicates the apparent mucosal coarsening of a section of an intestinal loop several minutes after the suspension was disintegrated artificially It is clear that continuous introduction of a large amount of contrast medium



Fig 9 Early mucosal abnormalities in Crohn disease easily differentiated in well filled case but difficult or impossible when the filling is moderate

into the small intestine is only guaranteed when the function of the pylorus is eliminated and the medium is introduced directly into the duodenum by infusion

Since most barium preparations on the market will withstand basic substances better than acid, the advantage of this method is that the detrimental effect of the mucin (FRAZER et coll 1949) and gastric juice is avoided The contrast medium must be hypotonic hypertonicity stimulates secretion from the intestinal wall and an isotonic solution adversely affects closing of the pylorus The addition of fats proteins and carbohydrates may inhibit peristalsis and therefore delay gastric emptying, even with partial gastrectomy Fewer peristaltic waves occur and the transit is retarded when the blood contains a high concentration of sugar and fats On the other hand a low concentration of these food substances in the blood may cause contraction of the stomach and a feeling of hunger The diet must be of low residue for 24 hours before the examination, with the last meal fat free It is also desirable that any medication that inhibits intestinal peristalsis should be withheld stimulation of the production of gall or contraction of the gallbladder should also be avoided

All these considerations suggested that the contrast medium should not be swallowed but should be introduced directly into the duodenum Routine ra



Fig 10



Fig 11



Fig 12

Fig 10 Abdominal survey after infusion of 600 ml contrast medium In pyknics and obesity in particular the position of the loops of the small bowel is usually clea

Fig 11 No masking even after the administration of 1 200 ml contrast medium

Fig 12 Loops of ileum freely separated by compression after introduction of 1 200 ml contrast medium and 1 700 ml water

diologic examinations of the small bowel have been carried out by infusion for the past 3 years and more than 1 500 patients have been examined The rate of flow proved to be most effective when 600 ml medium were administered in 5 to 6 minutes the caecum had already been reached by the end of the infusion period in 33 per cent of the patients and only several minute later or after a supplementary dosage of 300 ml medium or water in a further 33 per cent The retarded transit in the remaining patients was caused by various factors organic as well as functional A supplementary dosage of 600 ml medium or water is



Fig 13 Loops of ileum in true pelvis separated by compression after rectal and oral insufflation with air



Fig 14



Fig 15

Fig 14 Abdominal survey after air insufflation through duodenal tube

Fig 15 A thin layer of barium covers the mucosa of the small intestine after the introduction through duodenal tube of 600 ml medium followed by 600 ml water

usually necessary for the caecum to be reached quickly It has become apparent that a full ascending colon or treatment with drugs that produce intestinal atony are the most common causes of retarded passage Thorough preparation of the patients is therefore exceedingly important Another advantage of this is that after the examination of the small intestine it may be flushed with water enabling films to be obtained of the colon outlined with the contrast medium (Fig 7) even the double contrast technique may still be employed after the oral or rectal insufflation of air (Fig 8) It should be stressed that cleansing of the colon must be carried out by the oral route only and not by means of a rectal enema since many patients appear unable to empty the caecum completely after an enema reflux of the enema into the caecum has also been known to occur In addition to a marked retarding effect on the transit time in the ileum problems of interpretation arise due to the mixing of the enema with the medium flowing in from above Also unfavourable for rapid transit through the small bowel is reduced peristaltic reflex in the duodenum caused by reflux of the medium into the stomach This is almost always a result of an incorrect intubation technique or

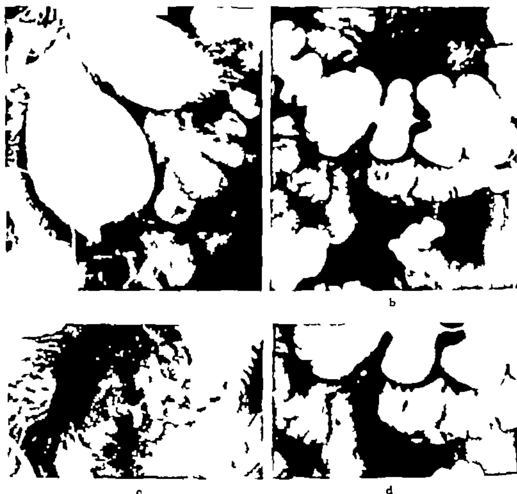


Fig 16 Small reticulum cell sarcoma of small intestine evident with fusion technique ( ) Rapid administration of contrast medium causing prestenotic dilatation ( ) detail of tu our ( ) The tumou escaped notice in the conventional examination (b d) although large mount of medium (900 ml) was admi istered No dilatation f the small intesti (b) deta l f tumour rea (d)

faulty positioning of the tube Reflux may also sometimes result from either disturbed pyloric function due to drugs causing atony or too sharp an angle be tween the aorta and the superior mesenteric artery in highly emaciated patients

The rapid administration of these larger amounts of contrast medium always enables the loops of the small intestine to be examined in a well filled state A significant advantage of this is that small irregularities of the mucosa are less likely to be missed than when the same loops are slightly contracted (Fig 9) An

attempt should therefore always be made to obtain films not only of the bowel when moderately filled but particularly when it is dilated, especially in the distal ileum where most abnormalities occur The largest amounts of medium (max 1 200 ml) and water are necessary in paralytic ileus, ileus caused by obstruction scleroderma and similar conditions Up to 1 800 ml or more (max 2 400 ml) may then be necessary to reach the colon or the obstruction in 30 or 60 minutes or more

Two extremely important factors that still fail to receive enough attention are the specific gravity of the contrast medium and the optimum exposure it demands The specific gravity chosen is usually much too high and in addition the films are generally underexposed An extensive series of experiments was performed with plastic tubes of varying diameter in a water phantom 20 cm thick Barium suspensions of different specific gravity and wooden beads 5 to 12 mm in diameter were placed in the tubes These experiments suggested that if the exposure technique is suitably adapted, the radiologic examination of the small intestine of a normal patient may best be carried out with a contrast medium of 1 25 specific gravity This should be increased to 1 3 for an obese patient and decreased to 1 2 for a thin patient a child of 4 to 8 years usually needs a specific gravity of 1 15 (SELLINK 1971) It is worthwhile noting that when the specific gravity of the contrast medium is properly chosen 600 ml will never cause superposition of other intestinal loops (Fig 10) and 1 200 ml will seldom do so (Fig 11) Even with total fluid amounting to 1 800 or 2 400 ml it is still possible with adequate compression to project the separate loops freely (Fig 12) If despite a prone tilted position and a compression balloon between the lower part of the abdomen and the couch top it is still not possible to move loops of the ileum out of the pelvis a supplementary insufflation of air rectally or orally may prove of value (Fig 13) The inclusion of the double contrast technique with air (Fig 14) or water (Fig 15) may lengthen the duration of the examination by 5 or 10 minutes but the roentgenograms obtained are quite often informative and usually justify the extra effort

Discussion

Thickening of the barium suspension at the site of an obstruction in the small intestine has often been feared although no case appears to have been reported On the other hand it seems that the medium tends to become thinner in a dilated intestinal loop Slight relative obstructions may also be demonstrated with the rapid infusion technique since prestenotic dilation is temporarily induced something not possible with the oral administration of contrast medium Fig 16)

It is a misconception to assume that films that permit accurate anatomic eval

uation of the small intestine can be obtained as long as the barium is introduced into the duodenum through a tube. SCHATZKI (1943), LURA (1951), SCOTT HARDEN et coll. (1961) and PYGOTT et coll. (1960) also administered the medium directly into the duodenum although they failed sufficiently to consider the fact that a number of other, equally important, requirements must also be satisfied if optimum films are to be obtained. It goes without saying that knowledge of the physiology of the small bowel is necessary for an understanding of the factors that have been mentioned. SCHATZKI and LURA were also handicapped because intubation was not always successful and usually required a great deal of time. SCOTT HARDEN and PYGOTT employed a somewhat better technique for intubation but the amount of contrast medium they introduced was much too low. Development of the Bilbao-Dotter tube (BILBAO et coll. 1967) signified a great improvement: after some practice, the tube may be introduced in only a few minutes and can probably be handled by a nurse or radiographer.

It is however easier as well as safer to use the extended Bilbao tube now on the market: it can be inserted further—to the duodenum—and the feed line can never perforate the stomach through the tube openings. In order to avoid curling in the cardiac end of the stomach the tube must be swallowed with the patient sitting or standing; it is then manipulated until the end lies approximately in the pyloric antrum. The feed line is inserted, the patient then lies on the right side and under fluoroscopic supervision is directed to push the tube further himself. A flexible end, 8 to 10 cm in length, makes the passage through the pyloric canal easier. With markedly ptotic stomachs the flexible end of the tube should be even longer, say 15 to 20 cm. Finally the tube is introduced further while the feed line is continuously pulled back until Treitz's ligament is reached. Visual control need be only intermittent and should be executed with a small field and a moderate roentgen dosage: after some practice it is usually possible to limit the exposure time during the introduction of the tube to 10 to 20 sec.

Conclusion

Radiologic examination of the small intestine by means of infusion with contrast medium would appear to save considerable time. In addition the information obtained is far superior to that achieved from conventional methods of examination; in fact for obstructions and the differential diagnosis of diseases accompanied by malabsorption it is the only choice since disintegration of the emulsion, regardless of the brand, no longer occurs. It would seem therefore that the oral administration of the medium, even by the MARSHAK method, should be abandoned or at the most only employed in emergencies, such as in mentally disturbed patients in whom intubation sometimes proves to be difficult.

SUMMARY

The radiologic examination f the small intestine would appear to be best performed by th technique of infusion following duodenal intubation A material of over 1 500 patients is reviewed and the method is described in detail and discussed The procedure is far from new but has never been used on a large scale Since duodenal intubation today takes only few minutes the technique again deserves attention

ZUSAMMENFASSUNG

Als beste Method fur die Rontgenuntersuchung des Dunndarmes wird die Infusion on Barium durch eine Duodenalsonde empfohlen Ein Material von 1 500 Fallen wird mittels dieser Method untersucht dies wird detailliert beschrieben und besprochen Obwohl die Methode keineswegs neu ist hat sie niemals Anwendung in diesem Massstab gefunden sie erdient besondere Beachtung da mit genugend Erfahrung nur wenige Minuten zu deren Ausubung benotigt werden

RÉSUMÉ

L examen radiologique de l intestin grele parait etre meilleur par la technique de l injec tion apres tubage duodenal Une serie de plus d 1 500 Malades est passee en revue et cett methode est decrit en detail et etudiee Cette technique est loin d etre nouvelle mais ell n jamais et utilisee sur une large echell Étant donne que de nos jours le tubage duodenal ne prend que quelques minutes ett technique merite nouveau l ttention

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INSTRUMENT FOR THE REMOVAL OF A GASTRIC BEZOAR

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Bezoar are not commonly encountered in gastroenterologic roentgenology A survey of the literature indicates that trichobezoar usually occur in neurotic or mentally disturbed patients on the other hand phytobezoar consisting of fibrous vegetable and fruit are encountered in otherwise ordinary patients It is generally accepted that disturbance of gastric motility may often be an underlying factor as the incidence appears to be certainly more frequent after vagotomy and in patients with a history of gastric surgery (KIRKS & SZEMES 1971) However the reason for the foreign body is not always apparent and it may be reasonable to assume that anticholinergic drugs and antacids have some bearing (KIRKS & SZEMES)

A means has been obtained for the removal of gastric foreign bodies without surgery and was initiated by the presence of a bezoar 4 cm × 5 cm × 3 cm in size in a 35 year-old male physician Gastroscopy was initially performed following roentgen examination in an attempt made to break up the [illegible] The procedure was unsuccessful and as the patient refused operation [illegible] native was devised in a simple instrument constructed from ordi[illegible] ally available in cardiovascular radiologic departments Two 0 [illegible] wire of the cardiovascular type and 150 cm in length were passed t[illegible] [illegible]posing

Submitted for publication 7 May 1975



Fig 1



Fig 2

Fig 1 Bezoar in the basket in the oesophagus

Fig 2 Specimen in the basket

side holes and looped at the distal end of polythene tubing (ID 7 mm and 70 cm in length) The proximal ends were taped, as were the crossed loops, at the distal end, thus creating a basket by pushing and pulling the guide wires in the tube the size of the basket could be so reduced so as to enable it to be introduced into the stomach A small amount of barium emulsion outlined the bezoar and minor manipulation enabled it to be slowly withdrawn with only minimal oesophageal discomfort The entire procedure was accomplished in approximately thirty minutes with the patient able to take nourishment almost immediately afterwards The examination was continuously controlled by TV fluoroscopy (Figs 1—3)

Discussion

This is a rare phenomenon although one that has been much discussed The initial symptoms are usually vague while the signs of obstruction are typical due to the usual situation of the bezoar in the prepyloric area Almost all bezoar are diagnosed by roentgenology except when they adhere to the stomach wall and are small in size (McKechnie 1972)

This would appear to be the first report of the removal of a bezoar from the stomach under fluoroscopic control It has been stated that the medical treat

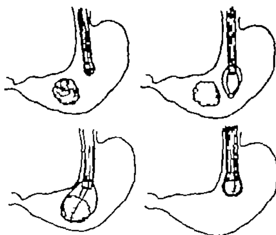


Fig 3 The instrument in the open and lo ed positions to manipulate the be zoa

ment of these bodies has been successful in a series of 4 patients (COHEN & STREKA 1968) The present patient had had no operation and there was no history of any significant gastrointestinal symptoms he had however eaten a large number of persimmon (date plums) about 6 weeks previously Analysis of the mass confirmed that it was formed of vegetable fibres

Although the treatment of bezoar by gastroscopy as well as by medical manage ment has been reported before it was felt that the introduction of this new me thod might be of some value it appears to contain promise in those cases that cannot be managed by the traditional methods

SUMMARY

A simple and effectiv method of removing foreign bodies from th oesophagus and stomach under TV fluoro copy control is described including its pplication in an adult male ith phytobezoar in the stomach

ZUSAMMENFASSUNG

Eine einfache und wirksame Methode fur die Entfernung on Fremdkorpern us dem Osophagus und dem Magen unter fluoroskopischer Kontrolle wird angegeben Die An wendung der Methode in dem Fall eines erwachsenen Mannes wird als Beispiel angefuhrt

RÉSUMÉ

Description d une methode simple et efficace d extraction des corp etranger l l phag et de l estomac sous controle d radioscopie televisee y compris son ppl l un homme adulte ayant un phytobezoar de l estomac

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THE VESTIBULAR AQUEDUCT AND THE PARA VESTIBULAR CANAL

An anatomic and roentgenologic investigation

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Advanced oto surgery in cases of Menière's disease has initiated preoperative tomography of the temporal bone (CLEMIS & VALVASSORI 1968, BRUNNER & PEDERSEN 1971, SESANA et coll 1971, WILBRAND 1971, BIRCH & BARRIONUEVO 1972)

The membranous labyrinth with the cochlear and vestibular receptor organs has contact with the posterior fossa by the endolymphatic duct in the vestibular aqueduct (Fig 1) The endolymphatic duct ends with a blind sac, saccus endolymphaticus, on the cerebellar surface of the pyramid between two sheets of the dura Much interest has been focused on the duct and sac in investigations of the aetiology and treatment of Menière's disease

Extensive anatomic and embryologic examinations of the inner ear have been reported by BAST & ANSON (1949) and ANSON et coll (1965, 1967, 1968) primarily as a basis for surgery

Additional measurements have been performed by OGURA & CLEMIS (1971) who have also demonstrated a para vestibular bone channel, running from the vestibule to the posterior fossa close to the vestibular aqueduct

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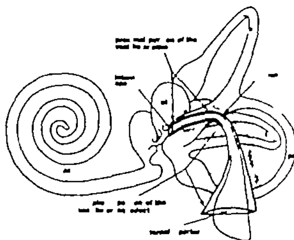


Fig 1 The membranous labyrinth and the vestibular aqueduct The aqueduct originates from the medial wall of the vestibule as a bony canal for the endolymphatic duct and sac The external aperture of the aqueduct is located on the cerebellar surface of the pyramid ssc—superior semicircular canal lsc—lateral semicircular canal psc—posterior semicircular canal cc—crus commune u—utriculus sc—sacculus

A comparative anatomic and tomographic investigation of the vestibular aqueduct has been carried out by BISCH & BARRIONUEVO (1972)

Proposed tomographic projections and the understanding of the possibilities of demonstrating the vestibular aqueduct have previously been based on limited experience In the present investigation tomography and subsequent micro dissections of specimens have been performed and the results compared with the aim of providing a reliable basis for clinical tomography A further purpose was to collect additional anatomic evidence of the existence of the para vestibular canal previously demonstrated by OGURA & CLEMIS on microdissection its importance is not yet fully understood

Anatomy

The vestibular aqueduct (Fig 1) forms a bony channel for the endolymphatic duct on its way from the vestibule of the inner ear to the cerebellar surface of the pyramid The aqueduct originates in the medial wall of the vestibule from a furrow (Fig 2) that gradually deepens to form its vestibular aperture and continues as a bony channel through the otic capsule, immediately in front of and somewhat medial to the crus commune of the superior and posterior semi circular canals (Figs 1 2 3 4) The first portion of the aqueduct has the same direction as the crus commune and follows its course to at least half the length of the crus or somewhat further to its division into the superior and posterior semicircular canals The aqueduct then bends, forming a more or less marked angle to continue its course under the bony plate of the cerebellar surface of the pyramid (Fig 3) The proximal portion of the aqueduct up to the bend

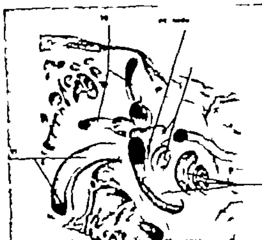


Fig 2

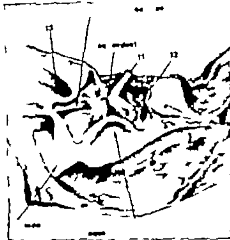


Fig 3

Fig 2 Internal picture of the vestibular aqueduct seen from inside the vestibule (redrawn and modified after PRASKOFF 1960) VII —facial nerve canal region of the lateral knee 10—lateral semicircular canal 11—superior semicircular canal Acu—area cribriformis utriculi Cv —crista vestibuli Acs—area cribriformis saccularis 8a b c—cochlea

Fig 3 Vestibular aqueduct seen from the posterior fossa The vestibular and cochlear aqueducts have been exposed by means of dental drill For topographic purposes bridges of bone was spared at the pore of the external aperture of the vestibular aqueduct 11—superior semicircular canal 1 —posterior semicircular canal 14—internal acoustic meatus

(isthmus) is narrow The peripheral portion gradually widens on its course to the cerebellar surface of the pyramid where it opens into the posterior cranial fossa as a slit like fissure the external aperture This is easily recognized about 10 mm postero-lateral to the opening of the internal acoustic meatus and 10 mm inferior to the superior petrosal sulcus (ANSON et coll 1965 1968) The endolymphatic duct opens into the endolymphatic sac which is partly situated in the aqueduct with its pars rugosa and partly continues between two sheets of the dura outside the external aperture close to the sigmoid sinus

The endolymphatic duct on its way through the vestibular aqueduct is surrounded by loose connective tissue containing blood vessels which are especially abundant in the wider peripheral portion of the aqueduct with the pars rugosa There is no report that any major artery passes along with the endolymphatic duct through the aqueduct

The venous drainage of the labyrinth takes place partly through the vein of the vestibular aqueduct draining blood from the semicircular canals and the utricle This vein passes from the vestibule with the endolymphatic duct through the vestibular aqueduct penetrates the dura and opens into the sigmoid sinus Just before the sinus it receives numerous small veins from the rich venous plexus

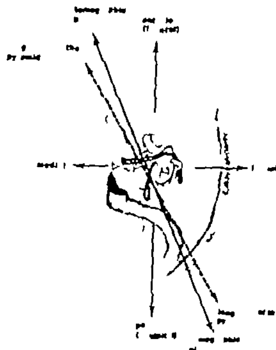


Fig 4 Orientation of the labyrinth in the axial view The course of the vestibular aqueduct is nearly parallel to the sagittal plane Tomographic plane as applied in tomography of the specimens The facial nerve is seen in its relationship to the cochlear and vestibular parts of the membranous labyrinth

around the endolymphatic sac (BAST & ANSON 1949) Vascular variations occur however (WOLFF et coll 1957 KELLNER & RICHTER 1962 ANSON et coll 1965 1968)

Histologically ANSON et coll (1965 1968) revealed the existence of vascular channels in close connection to the vestibular aqueduct and OGURA & CLEMIS observed both an artery and a vein in the para vestibular bone canal

Material Thirty five temporal bone specimens obtained from non selected autopsy cases (22 male and 13 female individuals of ages 5 to 75 years mean 56 years in 9 cases bilateral) were examined

Methods The specimens were mounted on a plexiglass holder with the intention of simulating clinical positioning (Fig 5) It was found difficult however to position the isolated temporal bone correctly without it being in reference to other skull structures

Tomography was performed with a Polytome, using its hypocycloid movement and with a magnification factor of 1 3 focus size 0 3 mm exposure data 50 to 55 kV 50 mA 5 8 s (one hypocycloid movement) high definition screens (Siemens Rubin) and RPL film processed in a 90 s Pakorol machine at 35 C

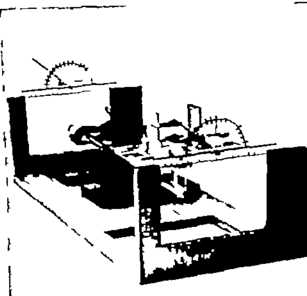


Fig 5 Plexiglass holder for tomography of the temporal bone specimens

The specimens were tomographed at an inclination of 20 to 25 from the lateral projection towards the long axis of the pyramid (Fig 4) which meant that the tomographic plane in the pyramid was at an angle of 20 to 25 to the sagittal plane The distance between the cuts was 0 5 mm to guarantee over lapping of information contents from one tomogram to the next

Measurements were carried out with a vernier caliper (division 1/10 mm) under optimal viewing conditions i e carefully shaded viewing of each tomogram in a 6-tenogram by means of a mask with a density of 1 5 to 1 8 at the ordinary viewing box and subdued illumination of the environment (ROTLER 1967)

The distance from the internal aperture of the aqueduct to the bend and the distance from the bend to the external aperture were assessed by three viewers independently on repeated occasions Exact assessment of measurement points at the external aperture was difficult in some cases and to a lesser degree also at the internal aperture due to low contrast

After tomography the specimen was stained with 4 % OsO_4 solution in a phosphate buffer which was injected through the oval window and the external aperture of the aqueduct Staining provided guidance on drilling Under a dissection microscope bone tissue was removed with a dental burr to expose the vestibular aqueduct The otic capsule of the superior and posterior semicircular canals was saved (Figs 6 7) The course of even very gracile para vestibular canals could be followed These canals and the aqueduct were carefully opened At the external aperture a small bone bridge (operculum) was saved for mea



Fig 6 Dissected temporal bone The vestibular aqueduct (av 1 and av 2) and the para vestibular canal (pv) from the medial aspect The exposed aqueduct exhibits relatively straight course through the pyramid with a recess like widening of the peripheral part (av 2) For topographic purpose bridge of bone was saved t the external perture (pt ext) The para vestibular canal is visible medially and below the aqueduct with small channel (ch) communicating with the aqueduct in the immediate vicinity of the crus commune The peripheral mouth of the para vestibular canal is located in the immediate vicinity of the external perture of the aqueduct Wide angle between the proximal (av 1) and peripheral parts (av 2) of the vestibular aqueduct The internal acoustic meatus (mai) exposed demonstrating the transverse crest subdividing the lateral fundus of the meatus



Fig 7 Dissected temporal bone The vestibular aqueduct (av 1 and av 2) from the occipital aspect The proximal part (av 1) runs fairly parallel t the crus commune At the bend (isthmus) the dimension f the aqueduct is small (0 1 mm) subsequently slight widening of the peripheral part (av 2) A bridge of bone was saved t the external perture (pt ext) The para vestibular canal is situated beneath the aqueduct (not visible in the photograph) The superior (ssc) and the posterior (psc) semicircular canals re imagined rising from the crus commune in the rear of the proximal part (av 1) and th isthmus of the aqueduct Small angle between the proximal and peripheral parts of the aqueduct (compare with Fig 6) mai—internal acoustic meatus

T bl 1

Results of m asurements of the vestibular aqueduct in tomograms of isolated human temporal bone specimens

	Mean alue mm	Range mm	Standard deviation mm SD	Number of obser tions
Total length ewer 1	8 20	5 7 11 0	1 47	33
Total length ewer 2	8 05	5 5 –10 1	1 33	35
Total length ewer 3	8 0c	5 4 –11 8	1 44	35
Total length all obser tions	8 10	5 4 –11 8	1 28	103

Tabl 2

Result of measurements of vestibular aqueducts in dissected human temporal bone preparations

	Mean alue mm	Range mm	Standard deviation mm SD	Number of bser tions n
Total length of the aqueduct	8 47	6 1 –12 6	1 54	35
Length of the proximal portion of th aqueduct	2 1	1 2 –3 0	0 60	35
Length of the peripheral port on of the aqueduct	6 30	4 0 –9 9	1 35	3
Width of the nternal perture	0 67	0 4 –1 0	0 17	3
Smallest width of the queduct	0 2	0 1 –0 4	0 09	34
Height of the external perture	0 8	0 2 –1 4	0 27	34
Breadth of he external aperture	6 46	3 1 –15 0	2 35	35

surement of the height and width of this aperture The flat triangular widening of the peripheral portion of the aqueduct was saved for assessing variations of its shap in different temporal bones

Measurements of the stained specimens were performed on different occasions by means of an optic scale (1/10 mm) in the dissection microscope

For assessment of variations of the course of the aqueduct in relation to the superior semicircular canal the specimens were photographed in the vertical direction In enlarged photographs variations of an inherent lateral curving of the aqueduct could be assessed The angle between the proximal and peripheral portions of the aqueduct was estimated with the aid of simple optic enlargement and a square rule

Results

Measurements on tomograms The mean total length of the vestibular aqueduct was 8 1 mm (range 5 4 to 11 8 SD 1 28) The differences between the three viewers results of iterated measurements were very small (Table 1) The total length of the aqueduct is composed of the sum of the length of the proximal portion—the distance from the internal aperture to the bend (isthmus) of the aqueduct—and that of the peripheral portion—the distance from the external aperture to the isthmus The measurement point at the bend was represented by its vertex situated at the mid height of the crus commune or somewhat higher up towards its division into the superior and posterior semi circular canals The values obtained for the proximal and peripheral portions of the aqueduct are not specified in Table 1 owing to difficulties in defining the measurement point exactly at the bend in cases where this was more like a curve than an angle The measurement point at the external aperture was the tip of the bone bridge (operculum) overhanging this aperture The measurement values in the films were reduced to natural size (the tomographic magnification factor was 1 3)

The entire aqueduct was observed in 51 per cent of the cases that part of the aqueduct which could not always be identified was the proximal portion or the isthmus A para vestibular bone canal could be discerned in 7 of the 35 cases (20 per cent) (Fig 9 c)

Measurements on specimens The results of direct measurements on the specimens are presented in Table 2 The measurements revealed that the total length of the aqueduct is mainly influenced by the length of the peripheral part (correlation coefficient total length—peripheral part 0 91 highly significant total length—proximal part 0 45 significant) The mean length of the proximal part was 2 15 mm and that of the peripheral part 6 3 mm The mean total length of the aqueduct was 8 47 mm (Table 2) The internal aperture could not be measured from the vestibule, as has been done by other authors (ANSON et coll 1965 1968 OGURA & CLEMIS 1971) instead following the proximal part of the opened aqueduct in the direction towards the vestibule, at the mouth of which a thin bone shell was preserved, the diameter of the mouth was measured This procedure might have influenced the objectivity of the measurement in view of the difficulties in finding the correct anatomic measurement points

The location of the narrowest part of the aqueduct varies but it lies at or in the vicinity of the bend

Exact measurement of the external aperture is difficult owing to its irregular shape In the present material its height is given as the mean value of the longest vertical distance

Tabl 3

Additional observations and results of direct measurements of the vestibular aqueduct and para vestibular canal in human temporal bone specimens

Angle between proximal and peripheral portion of the aqueduct	90 – 135
Lateral curving of the aqueduct	9/35 (26)
Recess like widening of the peripheral portion of the aqueduct	11/35 (31)
Para vestibular canal observed at dissection	35/35 (100)
Para vestibular canal localized lateral to the aqueduct	9/35 (26)
Mean width of para vestibular canal	0 12 mm (range 0 1 – 0 2)

Additional observations and anatomic measurements of aqueducts and para vestibular canals are presented in Table 3 In the anatomic preparations the angle between the proximal and peripheral portions of the aqueduct was 90 to 135 Generally speaking it seems as if long aqueducts have a smaller angle between the proximal and peripheral portion and vice versa (Figs 6 7)

A laterally curved deviation of the aqueduct from its otherwise straight course through the pyramid (viewed in the axial projection) in relation to the superior semicircular canal could be observed in 9 of the 35 specimens (26 per cent)

The width of the aqueduct increases from the isthmus to the external aperture with considerable variations from case to case (Figs 3 6 7) The bony wall of the flat peripheral portion may be irregular with clearly discernible furrows and often canalicular openings Similar but less evident irregularities may also occur in narrower portions of the aqueduct The peripheral portion may occasionally be narrow with only a hint of a triangular widening (Fig 7)

The width of the external aperture (mean value 6 46 mm) was related to the length of the peripheral portion of the aqueduct (correlation coefficient 0 47 significant) the longer the peripheral portion of the aqueduct the greater the width of the external aperture The peripheral portion usually appeared as a regularly flat triangular widening which however sometimes extended laterally forming a pouch or recess (Fig 6) Such appearances were observed in 11 of the 35 specimens (31 per cent)

Close to the aqueduct a para vestibular canal was observed in every specimen (Figs 6 11 Table 3) It ran at a short distance medial to and somewhat

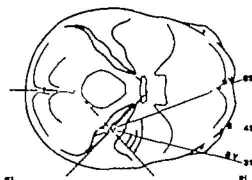


Fig 8 Orientation of the vestibular aqueduct reference to the superior semicircular canal in the skull base 71 mean inclination of the vestibular aqueduct (a) is 45 (range 31 —65) reference to the plane of the superior semicircular canal (ssc) On the assumption that the superior semicircular canal is located perpendicularly to the longitudinal axis of the pyramid at an inclination of 45 to the sagittal plane of the skull base the course of the vestibular aqueduct is on the average parallel to the film plane in the true lateral projection

beneath the aqueduct through the temporal bone from the vestibular wall to the external aperture where it had a separate opening The width of the canal varied between 0 1 and 0 2 mm (mean value 0 12 mm)

In two cases a duplicate canal could be seen originating from the vestibule communicating with the aqueduct and joining near the external aperture In some cases the peripheral portion of the para vestibular canal emerged into the floor of the external aperture near the foveate impression for the endolymphatic sac

The para vestibular canal was localized lateral to the aqueduct in 9 of the 35 specimens (26 per cent) (Table 3) In 2 only the peripheral part was observed and thus followed the peripheral portion of the aqueduct on its lateral side the proximal parts were assumed to run directly beneath the aqueduct and for technical reasons could not be explored by dissection In these two cases the canal had its orifice on the lateral side of the external aperture

The para vestibular canal in one specimen ran adjacent to the aqueduct in its proximal part but diverged at the bend and emerged in close proximity to the external aperture In a few specimens openings of vascular canals were evident in the wall of the peripheral, triangular part of the aqueduct

Comparison between measurements on tomograms and on temporal bone specimens The measurements on the tomograms and on the dissected temporal bone specimens showed good agreement (correlation coefficient 0 55) (Fig 10) The mean of the total length of the aqueduct on tomograms for all three viewers was 8 1 mm while that on specimens was 8 47 mm An aqueduct with a diameter of 0 1 mm measured on a dissected specimen could be discerned in the tomogram (Fig 9 a)

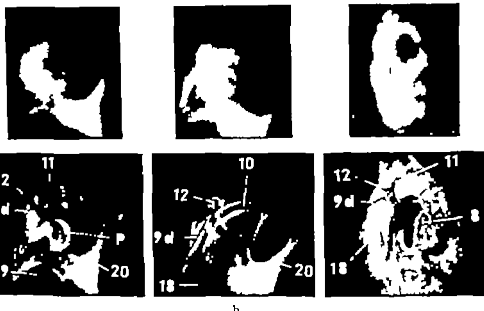


Fig 9 Tomograms of the vestibular aqueduct (projection see Fig 4) b) Tomographic reproduction of small vestibular aqueduct its anatomy exposed by dental drill in Fig 7 The specimen represents variant of the vestibular aqueduct with narrow proximal part (Measurements on microdissection narrowest width 0 1 mm immediately peripheral to the bend of the aqueduct length of the proximal part of the aqueduct 1 7 mm length of the peripheral part 9 9 mm breadth of the external aperture 6 7 mm width of the internal aperture 0 4 mm angle between proximal and peripheral parts 90 plane of the aqueduct 33 in reference to the plane of the superior semicircular canal)) Tomographic reproduction of the specimen in Fig 6 Short wide aqueduct and discernible paravestibular canal beneath the aqueduct (Measurements on microdissection narrowest width of the aqueduct 0 25 mm at the bend Length of the proximal part 3 mm peripheral part 5 6 mm recess-like widening of the peripheral part Breadth of the external aperture 6 5 mm width of the internal aperture 0 8 mm angle between proximal and peripheral portions of the aqueduct 135 plane of the aqueduct 50 in reference to the plane of the superior semicircular canal) 9d—vestibular aqueduct 8—cochlear coils 10—ampulla structures of the lateral semicircular canal 11—superior semicircular canal 1 — posterior semicircular canal 18—sigmoid sinus 19—jugular fossa 20—tympanic bone P—promontory

Discussion

Previous reports on tomography of the vestibular aqueduct (JUSTER & FISCHGOLD 1955 AGAZZI et coll 1958 CLEMIS & VALVASSORI 1968 BRUNNER & PEDERSEN 1971 SEBANA et coll 1971 WILBRAND 1971 BISCH & BARRIONUEVO 1972) have discussed positioning for demonstration of this structure Insertion of a metal thread into the aqueduct (CLEMIS & VALVASSORI BRUNNER & PEDERSEN) and injection of small quantities of contrast medium into it served as aids for demonstrating its course through the pyramid BISCH & BARRIONUEVO examined 30 temporal bone specimens in order to assess morphologic variations

Table 4

Measurements of the vestibular aqueduct at microdissection Comparison of results obtained by different authors

	Anson et coll (196[illegible] 1968)	Ogura & Clemis (1971)	Present investigation
Width of the [illegible]ternal [illegible]perture	0 35 mm (0 25–0 50)	0 3 mm (0 2–0 6)	0 [illegible] mm (0 4 [illegible] 1 0) SD 0 17
Width of the [illegible]queduct at the isthmus	0 [illegible] mm ([illegible]arrowest 0 17)	0 3 mm (0 2–0 4)	0 24 mm (0 1–0 4) SD 0 1
Total length	8 5 mm	8 7 mm (5 0–12 0)	8 47 mm ([illegible] 1–1[illegible] [illegible]) SD 1 54
Length of the proximal portion		1 4 mm (1 0–1 9)	2 2 mm (1 [illegible]–3 0 SD 0 6
Length of the peripheral portion		7 3 mm (4 0–10 0)	6 3 mm (4 0–9 8) SD 1 3
Width of the external [illegible]perture	7 mm (1 0–13 0)	[illegible] 2 mm (5 0–9 0)	6 5 mm (3 1 [illegible] 1[illegible] 0 SD 2 35
Height of the external [illegible]perture	0 [illegible]3 mm		0 8 mm (0 [illegible] 1 4) SD 0 3

in the course of the aqueduct but were unable to demonstrate its proximal portion tomographically There is no comment on the radiographic system and technique used except that the Polytome with its hypocycloid movement was employed and that a focal size of 0 6 mm was used

The examinations of Clemis & Valvassori on patients were performed on the Polytome but it is not clear from their report to what extent a focal spot of 0 3 or 0 6 mm and different projections were used The distance between the cuts was 0 5 to 1 mm The authors considered that the failure to demonstrate the aqueduct in their material of Meniere s disease was not due to technical factors

Visual perception of delicate structures in tomograms is dependent not only on their dimension but also to a high degree on their shape The length and course of the aqueduct on tomograms and in dissected specimens were therefore compared to evaluate the reliability of the tomographic image This comparison

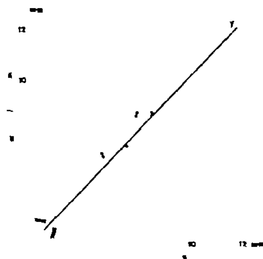


Fig 10 Comparison of measurements of the vestibular aqueduct (total length) in 35 fresh human temporal bone specimens on dissection and in their tomograms The reduced values (tomographic enlargement factor 1 3) from the tomograms are in general smaller than the dimensions in the anatomic specimens

showed good agreement The individual results of the three viewers differed only slightly A comparison between the results obtained in this material and measurements reported by ANSON et coll (1965 1968) and OGURA & CLEMIS (1971) also showed good agreement on the whole (Table 4)

The mean length of the proximal portion of the aqueduct was 0 8 mm greater in our material than in that of OGURA & CLEMIS and the length of the peripheral portion 1 mm shorter the vertex of the bend (isthmus) of the aqueduct serving as measuring point in both investigations The position of this vertex was sometimes difficult to assess and the three viewers did not always agree except in cases where it consisted of an obvious angle between the proximal and peripheral portions of the aqueduct

The mean width of the internal aperture of the aqueduct has been found by ANSON et coll (1965) to be 0 35 mm On specimens OGURA & CLEMIS (1971) made measurements of this aperture from the inside of the vestibule in two dimensions the vertical diameter having a mean value of 0 3 mm (0 2 to 0 6) and the horizontal diameter 0 2 mm (0 2 to 0 4) ANSON et coll do not specify their procedure but their results are in good agreement with those of the former authors The mean value of 0 6 mm (0 4 to 1 0) obtained in the present material is based on a different method of measurement which may explain the discrepancy

The shape of the external aperture of the aqueduct varied extensively but the values in the present material are nevertheless in good agreement with those of the authors mentioned (Table 4)

The angle between the proximal and peripheral portions of the aqueduct



Fig. 11. Plastic mould of the inner ear, revealing the delicate structures of the aqueduct and the para-vestibular canal from the vestibule to the posterior surface of the pyramid, seen from below. av 1—proximal part of the vestibular aqueduct; av 2—peripheral part of the aqueduct; pv—para-vestibular canal; ac—cochlear aqueduct; pcc—para-cochlear canal; mai—internal acoustic meatus; pan—posterior ampullary nerve canal; lsc—lateral semicircular canal; VII—tympanic portion of the facial canal; VIIb—site of the geniculate ganglion; cms—canal for the stapedius muscle; VIId and —lateral knee and mastoid part of the facial canal; rw—round window; ow—oval window; cct—canaliculus chordae tympani; VIIf—foramen stylomastoideum.

varied between 90 and 135 and had a negative correlation with the aqueductal length (correlation coefficient —0.3409): the shorter the aqueduct the wider the angle. In early foetal life the aqueduct has a fairly straight course, its proximal part running parallel and somewhat postero-medially to the crus commune and the peripheral part in a postero-lateral direction, emerging with the same orientation into the posterior fossa (Bast & Anson 1949). In the later half of foetal life when the inner ear has finished its growth but when the brain and the skeleton in the environment of the inner ear are still growing and the pneumatization of the temporal bone is taking place, the original straight course changes. The peripheral part of the aqueduct and the angle between the proximal and peripheral portions achieve their final shape and the final dimensions of the different parts and the total length of the aqueduct are attained.

The peripheral part of the aqueduct had a laterally curved course in 9 of the 35 cases (26 per cent). Such a curve as well as variations of the angle between the proximal and peripheral parts are mentioned by Ogura & Clemis (1971). The curve may be an expression of growth dynamics. The same applies to the development of the external aperture, with its great variety, which is obviously dependent upon growth factors in the posterior fossa (Anson et coll. 1965, 1968).

The pars rugosa of the endolymphatic sac, situated in the peripheral triangular portion of the aqueduct, takes a highly active part in the metabolism of the endolymphatic system (Lundquist 1965). In this material the mean width of the external aperture slightly exceeded the mean length of the peripheral portion

This implies that a long aqueduct provides a wider space for the endolymphatic sac than a short one The shallow recess at the peripheral part of the aqueduct was seen in 11 of the 35 specimens (31 per cent) (Fig 6) The wider this recess, the larger the space for the pars rugosa of the endolymphatic sac

An optimal reproduction of the aqueduct implies demonstration of its entire course from the internal to the external aperture in one single tomogram The width of the flat triangular peripheral portion of the aqueduct can be estimated from a consecutive series of cuts Thus the peripheral part may be assessed pre operatively with a fair degree of accuracy This may be valuable in the planning of shunt operations for Meniere s disease

The aqueduct generally ran in one plane in the pyramid An exception was seen in 9 of the 35 cases (26 per cent) where the peripheral portion curved laterally The plane of the vestibular aqueduct varied in general between 31 and 65 in reference to the plane of the superior semicircular canal (Fig 8) The latter plane is generally said to be at right angles to the long axis of the pyramid and to have a mean inclination of 45 to the sagittal plane of the skull (SOBOTTA 1952 PERNKOPF 1960 ROHEN 1971 JENSEN 1972) On the basis of this relation ship a common course of the aqueduct and its variations have been depicted in a schematic drawing of the skull base in Fig 8 which illustrates the most suitable projection in which the aqueduct can be expected to be properly reproduced in tomograms If it is not fully demonstrated in the true lateral view additional projections are necessary (Fig 12) If the aqueduct is smaller and also curves laterally in relation to the superior semicircular canal fundamental difficulties may arise in the tomographic reproduction Furthermore the longitudinal axis of the pyramid does not always follow the direction generally accepted to be 45 to the sagittal plane This means that the geometrical distribution of the superior semicircular canal in relation to other structures of the skull base is not constant (SCHONEMANN 1906) CLEMIS & VALVASSORI (1968) recommended a lateral or slightly modified lateral projection for demonstration of the aqueduct BRUNNER & PEDERSEN (1971) advocated similar positioning under visual control with a TV monitor The measurements on the specimens are in agreement with the statement by CLEMIS & VALVASSORI that the plane of the aqueduct is at a mean inclination of 45 to the longitudinal axis of the pyramid The tomographic plane used in this investigation thus proved not to be ideal and may explain the fact that the aqueduct was not demonstrated in a higher percentage of specimens Another possible source of failure is undue rotation of the isolated specimens The measurements on dissected temporal bones revealed that the plane of the aqueduct varied by about 15 to the one direction and 20 to the other from the mean value of 45 This may be of fundamental importance as such varia tions may give rise to unsatisfactory demonstration of the entire aqueduct in one

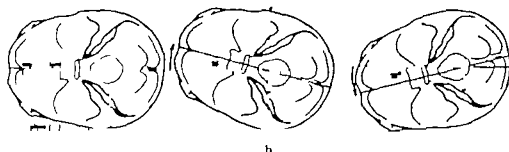


Fig. 12. Positioning in tomography of the vestibular aqueduct. a) True lateral. b), c) Complementary positioning in cases of unsatisfactory demonstration of the aqueduct in the true lateral projection.

projection (EDHOLM 1960, STIEVE 1972). In such cases the projection must be altered 15° to either side from the true lateral projection (Figs. 8, 12). In the present material 9 (26 per cent) of the aqueducts had a course through the pyramid beyond a 10° variation from the mean inclination of 45°. There are no means of screening, as the semicircular canals and the aqueduct cannot satisfactorily be discerned in axial views. In tomograms the true lateral projection primarily gave the best survey of the aqueduct.

In tomograms the para-vestibular canal was observed in only 7 of 35 temporal bones (20 per cent) but at microdissection it was regularly present. OGURA & CLEMIS on dissection of 23 temporal bone specimens found 12 clear canaliculi, 3 others were only partially observed while in 8 cases no channel was found at all. The authors assumed that failure to demonstrate the channel may have been due to technical factors in the microdissection, a failure of the staining capabilities or its true absence. In the present material the channel was always revealed in the preparations and only with an anatomically divergent course did preparatory difficulties arise, which do not make its regular existence questionable.

The interrelationship between the para-vestibular channel and the aqueduct was first discussed by OGURA & CLEMIS. ANSON et coll. (1965, 1968) have mentioned the existence of small vascular channels along the course of the vestibular aqueduct conveying vessels to and from the connective tissue around the endolymphatic duct and sac. However, they have not claimed the existence of a regular channel, which by histology (OGURA & CLEMIS) has been found to contain both an artery and a vein, supported in loose connective tissue. The present investigation has proved the regular existence of a para-vestibular canal with some typical variations in its course alongside the aqueduct. The connection between this channel and the contents of the vestibular aqueduct is obvious, as small vessels pass from the para-vestibular canal to the aqueduct and

by its peripheral opening in close vicinity of the external aperture or directly into it (Figs 6-11) The fact that the lumen, although its width varied between 0 1 and 0 2 mm could be demonstrated in tomograms of several specimens indicates that with the radiographic system used and under optimal viewing conditions visual perception of such structures may be possible

The failure to demonstrate the entire aqueduct in 49 per cent of the specimens in this material was probably due mainly to inadequate positioning but may also have been caused by extreme variations in the course of the aqueduct Visual perception of delicate structures with low image contrast may also be discussed as a matter of psychologic influence For that reason repeated measurements and evaluations of tomograms were performed on several viewing occasions A statement of visibility was based in every case on an unanimous decision by all three viewers that the entire aqueduct was visible on every viewing occasion

Conclusion

Progress in otosurgery has increased the demands for preoperative roentgenographic demonstration of the vestibular aqueduct Its anatomy has been incompletely known hitherto An investigation consisting of tomography and microdissection of temporal bone specimens has therefore been performed

The measurements on dissected temporal bone specimens confirmed the results of previous anatomic and histologic investigations concerning the length and width of the aqueduct and its course A recess like previously unreported widening of the peripheral part of the aqueduct was observed in 1/3 of the cases

Microdissection revealed that a para vestibular canal is present in every temporal bone It has a diameter of 0 1 to 0 2 mm Its topographic relationship to the endolymphatic sac opens up a new aspect of the vascularization of this structure

Tomography of the specimens proved the reliability of measurements on tomograms as compared with measurements on dissected specimens, a prerequisite for metric evaluation of tomograms in preoperative assessments of the aqueductal morphology

The demonstration of the aqueduct depends on very correct positioning For clinical examination an initial true lateral position is recommended If this gives an unsatisfactory result complementary projections with a 15 inclination on either side from the true lateral projection might be used before a final appraisal is made

With a proper technique and under optimal viewing conditions the entire length of the aqueduct can be observed even when its narrowest luminal diameter is only 0 1 to 0 2 mm Thus failure to demonstrate the aqueduct can be regarded as being primarily due to inadequate positioning or anatomic variation

The para vestibular canal had a diameter of 0 1 to 0 2 mm and was tomographically demonstrated in 7 of 35 (20 per cent) specimens

Computer processing of measurements on specimens and tomograms showed interrelationship between the dimensions of the aqueductal structures

SUMMARY

A comparative investigation of the anatomy as revealed by microdissection nd the multi directional tomographic features of the estibular aqued ct was performed in fresh isolated *temporal bone specimens Evidence was obtained f the reliability f nalysis and measure* ments of the queduct on tomograms The investigation elucidated th ariational natomy f th estibular aqueduct and its importance in th tomographic demonstration of this structure which w th otosurgical advances is becoming an increasing preoperative necessity Further evidence of th existence of a para vestibular canal and its association with the estibular aqueduct was produced

ZUSAMMENFASSUNG

In einer anatomischen und tomographischen Untersuchung frischer isolierter Felsenbeine w rde die Morphologie des Aquaeductus vestibuli dargestellt Dabei erw es sich dass bei entsprechender Technik tomographische Analyse und Messresultate ls zuverlassig bewertet werden konnen Weiterhin wurden die anatomischen Variationen des Aquadukts und ihre Bedeutung fur die tomographische Darstellbarkeit dieser Struktur klargelegt w lche bei ancierter Otochirurgie zu einer nutzlichen praoperativen *Massnahme geworden ist* Zudem konnt der Beweis der Existenz eines para estibularen Canal culus und dessen Z *ordnung zum Aquaeductus estibuli geliefert werden*

RÉSUMÉ

Les uteurs ont fait une etude comparative de l anatomie de l aqueduc du estibule examine par microdissection et de ses images pa tomographie multidirectionnelle sur des os temporaux frais isoles Ils ont etabli la fiabilit de l analyse et des mesures de l aqueduc sur les tomographies Cette recherche precise les ariations anatomiques d l aqueduc du esti bul et leur importan e pour la mise en evidence tomographique d ett structure qui devient un examen pre-operatoire de plus en plus necessaire en raison des progrès de l otochirurgi Ce travail a fourni une nouvelle preuv de l existence d un canalicul para estibulaire et de son association avec l aqueduc du estibule

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LUMBAR MYELOGRAPHY AND ADHESIVE ARACHNOIDITIS

L IRSTAM R SUNDSTROM and B SIGSTEDT

Several reports of adhesive arachnoiditis as late sequelae after lumbar myelography with water soluble contrast media have appeared in recent years (AHLGREN 1972 1973 AUTIO et coll 1972 BIDSTRUP 1972 HALABURT & LESTER 1973 IRSTAM & ROSENCRANTZ 1973 1974 RADBERG & WENNBERG 1973) IRSTAM & ROSENCRANTZ have shown the occurrence of arachnoiditis to be correlated with the local concentration of contrast medium as well as with the exposure time of leptomeningeal structures to the medium They also found an increased frequency of arachnoiditis following surgery after myelography

However the frequency of arachnoiditis varies from one published material to another It is not clear to which extent this variation is due to differences in technique or to the contrast media used This investigation was undertaken to elucidate the importance of these factors

Materials and Methods Out of 694 patients primarily examined with methyl glucamine iothalamate (Conray 60) 19 had been examined a second time

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Table 1

Frequency of adhesive arachnoiditis

Contrast medium at first examination	Patients not operated upon after first examination			Patients operated upon after first examination		
	Total	With adhesive arachnoiditis		Total	With adhesive arachnoiditis	
Kontrast U	19	8	42	10	6	60
Conray 60	9	1	11	10	1	10

Table 2

Changes of caudal root pockets

Contrast medium at first examination	Patients not operated upon after first examination with adhesive arachnoiditis		Patients operated upon after first examination with adhesive arachnoiditis	
Kontrast U	7	37	6	60
Conray 60	1	10	(1)	(10)

Nine of these patients (Group A) had not been operated upon before the second myelography while the remaining 10 (Group B) had been operated upon between the first and the second examination Of 800 patients primarily examined with methiodal (Kontrast U) 19 (Group C) were not operated upon and 10 (Group D) operated upon between the first and the second examination

The examination technique in the different series was that described by Irstam & Rosencrantz (1973) but with minor differences Myelography with Conray 60 4 ml of medium were mixed with an equal volume of CSF and as a rule the entire dose was injected through a Stenström needle with an outer diameter of 1 00 mm The head end of the examination couch was raised 10 to 15 and adjusted so that the contrast medium never reached higher than the upper border of the second lumbar vertebra This was checked by frequent exposures during injection no fluoroscopy was used Films were obtained with the beam horizontal and with the patient lying first on one side and then on the other always starting on the symptomatic side true lateral views were taken with the patient prone Finally p a views were obtained with the patient prone and the beam vertical

Table 3

Changes in root pockets Patients examined first with Kontrast U not operated upon (Group C)

Severity	Root pockets with changes			
	S 3	S 2	S 1	L 5
Grade 1	1	1	4	0
Grade 2	1	2	0	0
Grade 3	3	3	1	0
Grade 4	1	0	0	0
C de	1	0	0	0

Table 4

Changes in root pockets Patients examined first with Kontrast U operated upon (Group D)

Severity	Root pockets with changes			
	S 3	S 2	S 1	L 5
Grade 1	2	2	0	1
Grade 2	0	0	0	0
Grade 3	4	1	1	0
Grade 4	0	0	0	0
Grade	0	0	0	0

Myelography with Kontrast U 10 ml of contrast medium after spinal anaesthesia by 1 ml of heavy lidocaine (Xylocain) were injected through the same type of needle as in the Conray series The patients were examined only lying on the symptomatic side, then in prone position with the beam horizontal finally p a views with vertical beam and with the patient prone

After the examination the Kontrast U patients rested supine with the head end of the bed slightly raised for 4 hours and thereafter in horizontal position for approximately 20 hours the patients examined with Conray 60 rested for 10 hours with the head end elevated 45 and then for approximately 12 hours with the bed horizontal

The films and records of all patients were evaluated jointly by the authors Adhesive arachnoiditis was considered present when (1) the ends of one or more root pockets were rounded and corresponding nerves within such pockets were less well defined or (2) when a root pocket was not filled at all and the visibility of the corresponding nerve was impaired within the cul de sac near the obliter

Table 5

Changes in the cul-de sac

Contrast medium at first examination	Patients not operated upon after first examination with adhesive arachnoiditis		Patients operated upon after first examination with adhesive arachnoiditis	
Kontrast U	6	32	4	40
Conray 60	0	0	0	0

Table 6

Changes in root pocket cysts

Contrast medium at first examination	Patients not operated upon after first examination with adhesive arachnoiditis		Patients operated upon after first examination with adhesive arachnoiditis	
Kontrast U	2/	40	0/1	0
Conray 60	0/3	0	(1)/5	(20)

ted pocket, (3) when the cul de sac was constricted within an area with such root pocket changes and (4) when root pocket cysts were less well filled or not at all at repeat myelography

A local deformation of the subarachnoid space at the site of a previous operation for disc herniation was not interpreted as adhesive arachnoiditis

The changes due to adhesive arachnoiditis were graded as follows

(A) Impaired filling of root pockets Grade 1 Incomplete filling on one side normal on the other Grade 2 Incomplete filling on both sides Grade 3 No filling on one side normal on the other Grade 4 No filling on one side incomplete on the other Grade 5 No filling on either side

(B) Abnormalities in the appearance of the cul de sac its caudal extension in the spinal canal as well as of visibility of nerve roots in the caudal part of the subarachnoid space

(C) Root pocket cysts the extent to which they were filled and their appearance

Results

The frequency of adhesive arachnoiditis appearing at repeat myelography is given in Tables 1 to 6

Table 7

Frequency of adhesive arachnoiditis according to recalculated figures of AHLGREN *(1972 1973) and present series pooled with those of* IRSTAM & ROSENCRANTZ *(1973 1974)*

Contrast medium at first examination	Patients operated upon after first examination			Patients not operated upon after first examination		
	Total	With adhesive arachnoiditis		Total	With adhesive arachnoiditis	
Kontrast U/Conturex						
AHLGREN	138	60	43	50	5	10
Pooled series	60	45	75	51	18	35
Conray 60						
AHLGREN	55	29	53	16	7	47
Pooled series	13	3	23	12	1	8
Dimer X						
AHLGREN	32	23	72	11	4	36
IRSTAM & ROSENCRANTZ	12	5	42	7	0	0

Root pockets In the Conray 60 material root pocket changes were found in 1 case in Group A with grade 5 changes of the S3 pockets and 1 case in Group B with grade 3 changes of the S3 pockets

In the Kontrast U material, changes of the S3 root pockets of Group C were found in 7 of S2 in 6 and of S1 in 5 Corresponding changes in Group D were found in the root pockets of S3 in 6 cases of S2 in 3 of S1 in 1 and of L5 in 1 (Tables 3 4)

Cul de sac The cul-de sac was deformed only in the Kontrast U group (Table 5) The deformation was combined with root pocket changes in all cases except 1 of Group C At re-examination of this patient the cul de sac was 7 to 8 mm shorter than before and a slight narrowing of the cul de sac 5 mm above the caudal end of the subarachnoid space had occurred The shortening and the deformation of the cul de sac resembled what was seen in the other cases and as no other explanation could be offered it was interpreted as adhesive arachnoiditis at further myelographies typical and extensive arachnoid changes appeared which supported our assumption

In all patients with deformation of root pockets at repeat myelography the corresponding nerves in the cul de sac were only poorly visible near the origin of the pockets when the deformation was bilateral no nerves could be identified in that part of the subarachnoid space

Table 8

Frequency of adhesive arachnoiditis after second myelography

Procedure judged at subsequent myelography	No. of patients	New arachnoiditis	Accentuation of existing arachnoiditis	Unchanged adhesive arachnoiditis	No arachnoiditis	Frequency of new/accentuated arachnoiditis	
KxK	8	—	3	1	4	3	43
KxKop	6	1	4	—	1		83
KxC	3	—	—	1	2	0	0
KxCop	2	—	1	1	—	1	50
CxCop	2	—	1	—	1	1	50

K = lumbar myelography performed with Kontrast U
C = lumbar myelography performed with Conray 60
x = patient either operated upon or not after preceding myelography
 = no operation for disc herniation after preceding myelography
op = operation for disc herniation after preceding myelography

Root pocket cysts. Root pocket cysts were demonstrated at primary myelography in 3 patients in Group A, 5 patients in Group B, 5 in Group C and 1 in Group D. The cysts appeared at two or more levels bilaterally in all cases except in 1 in Group C where they were only unilateral. In a further case of Group C only one side was evaluable at primary myelography. At repeat myelography the root pocket cysts were always less well filled in connection with changes of the corresponding root pockets; in all these cases a deformation was also found at the corresponding level in the cul de sac (Tables 5, 6).

In one case examined with Conray 60 nearly all the medium was deposited subdurally at the primary examination; no structures within the subarachnoid space were demonstrable. Repeat myelography 9 days later revealed arachnoiditis of both S3 root pockets with a decreased definition of corresponding nerves.

Five months later the patient was re-examined with Conray 60; the impaired definition of the nerves in the lowest part of the cul de sac had extended 2 to 3 mm further cranially and was slightly more marked on that side where the contrast medium had had the highest concentration at the second myelography. Bilateral root pocket cysts, demonstrated at the second examination, were not filled at the third myelography. The patient's record contained a history of meningitis of unknown type 17 years earlier and rheumatoid arthritis during at least 15 years.

The changes observed at the second examination were considered to be present already at the first myelography being the only case in our series with a primary adhesive arachnoiditis In the statistical analysis the two first examinations were regarded as one the figures concerning this case are given in brackets in Tables 2 and 6

One case was excluded however it is the only case where arachnoiditis was confirmed at operation therefore some further details will be reported

The patient aged 37 had signs of a disc herniation of L5—S1 at the primary myelography performed with Kontrast U Operation revealed bulging disc but no true disc herniation At repeat Kontrast U myelography on the same side one month later total obliteration was found at the level of L5—S1 thus no structures could be demonstrated below this level and the case had to be excluded Operation following the second myelography revealed a large disc herniation which was removed

At a third myelography performed a further 19 months later and with the same technique and on the same side a slight postoperative local deformation at the level of L5—S1 was found also two small defects appearing as strands in the contrast medium were observed in the most caudal part of the cul de sac these defects might be explained as small strands of connective tissue due to adhesive arachnoiditis

A further 6 months later in all 26 months after the primary myelography attempts to perform a fourth myelography were unsuccessful Operation revealed a slightly reddened dura completely unelastic and without pulsations and surrounded entirely by fibrous tissue when the dura was opened further masses of fibrous tissue were found but no CSF This wide spread arachnoiditis was observed from the middle of L3 down to the middle of S1 Further surgery was considered meaningless

Our material includes 21 cases in which more than two myelographies had been performed (Table 8) The material is small especially in view of the fact that different techniques were used and surgery was performed in between the examinations in some of the patients Nevertheless, an analysis of the cases was considered worthwhile in order to get an idea of the extent to which previous myelography or surgery enhances the risk of arachnoiditis

In 13 of the cases arachnoiditis was found at the third myelography In 3 of them they had the same appearance as at the second but in 9 they had increased between the second and the third in these cases the arachnoiditis was very extensive with involvement of the most caudal part of the cul de sac as well as of the root pockets on both sides at several levels The thirteenth patient developed arachnoiditis after the second Kontrast U myelography

Discussion

Repeat myelography often reveals abnormalities of root pockets and adjacent structures in the most caudal part of the subarachnoid space differing from those of an extradural process such as a disc herniation or a local post operative

deformation It is widely accepted that such subarachnoid changes as described above are due to adhesive arachnoiditis though only few radiologically demonstrated cases have been confirmed at operation or autopsy (IRSTAM & ROSENCRANTZ 1973 1974) It is obvious that before the report of AUTIO et coll 1972 no effort had been made to reveal the factors contributing to the development of these adhesive arachnoiditic changes

In the present series the most severe adhesive arachnoiditis was found in the lowest part of the subarachnoid space it decreased in cranial direction (Tables 3 4) The arachnoiditis was always more marked on the examined side in the Kontrast U material (Group C and D) or on that side, examined first in the Conray 60 material (Group A and B) when arachnoiditis appeared bilaterally in any case of either group it was more extensive on the side examined first

In all our Conray 60 myelographies as well as in all with Kontrast U the radiologically highest concentration of the contrast medium appeared in the most caudal part of the cul de sac During the examination the concentration of the medium decreased uniformly probably partly owing to absorption partly to diffusion to other parts of the subarachnoid space This means that the arachnoiditic changes occurred where the concentration of the medium at preceding myelography had been highest and where the meninges had been exposed to the medium for the longest time

In the Kontrast U material of IRSTAM & ROSENCRANTZ both sides were examined by the method of HIRSCH et coll (1969) in the present material the patients were examined only lying on the symptomatic side and prone As a rule only the S2 and S3 root pockets on the contralateral side were then demonstrable Consequently root pockets and other structures above S2 level on the contralateral side could not be interpreted in most cases where repeat myelography was performed with Kontrast U The true frequency of bilateral arachnoiditis might thus be slightly higher than the figures given in the tables However the frequency of arachnoiditis in the present Kontrast U material was nearly equal to that in the series of IRSTAM & ROSENCRANTZ where both sides had been examined at the same myelography

In comparison between different materials the interval between the first and the second myelography must be considered since the arachnoiditis may require some time to develop In the present material the interval between the first and the second examination was somewhat shorter in the Conray 60 groups than in the Kontrast U groups

The interval between the two examinations of Group A ranged from 7 days to 24 months (mean 7 7 months) in Group B the interval ranged from 2 to 34 months (mean 9 months) while the corresponding figures for Group C were 4 days to 42 months (mean 15 5 months) and of Group D 4 to 90 months

(mean 24.5 months). The different intervals were nearly identical with those reported by IRSTAM & ROSENCRANTZ though none of their patients were re-examined within as short an interval as 4 or 7 days. In the present series the earliest case of arachnoiditis appeared 5 months after myelography with Conray 60, the corresponding interval after Kontrast U myelography was 4 months.

No positive correlation was found in any of the groups between frequency, spread and severity of adhesive arachnoiditis and interval between the examinations. This was in agreement with the report of IRSTAM & ROSENCRANTZ. The caudal extension of the cul de sac did not seem to have any influence on the occurrence of arachnoiditis in any of the groups.

The pathology of a disc herniation is well known (e.g. HADLEY 1964, BROWN 1971). However, only few reports on the irritating effects of such hernias on the meninges, sometimes producing arachnoiditis of a localized type have been published (FRENCH 1946, RANSFORD & HARRIES 1972). A diffuse and pearly white thickening of the leptomeninges with a fusion of the pia and arachnoid by fibrous and with foci of encroachment on the subdural space have been observed. The arachnoiditis may compress the spinal roots resulting in demyelinization, destruction of nerve fibers and even replacement of the nerve fibers by fibrous tissue. The vascularity of the pia is decreased and in some cases the pia is completely devoid of vessels (FEDER & SMITH 1962).

Following operation for a disc herniation a local scarring, i.e. an inflammatory and local process, either intra- or extradural, may occur (FRIBERG & HULT 1950).

The pathology of small, radiologically described arachnoiditis is absent. In a few cases (IRSTAM & ROSENCRANTZ) fibrous strands have been observed at opening of the dura during operation.

The radiologic appearance of a disc herniation in the lumbar region is well known as well as its correlation to pathology. Repeat myelography often reveals a local deformation at the site of a previous operation (CRONQVIST 1959, IRSTAM & ROSENCRANTZ 1974). This deformation might involve the root pockets, the roots and also the cul de sac. Such deformations can be regarded as a late sequela after a local trauma during surgery (FRIBERG & HULT).

Adhesive arachnoiditis on the other hand is usually more diffusely spread and always more marked in the most caudal part of the cul de sac, irrespective of whether surgery has been performed or not. Thus these abnormalities appear radiologically different to those of a postoperative deformation. Furthermore a local postoperative deformation might be found without co-existing adhesive arachnoiditis; in other cases an area with normal root pockets, roots and cul de sac may be observed between a local postoperative deformation and abnormalities caused by adhesive arachnoiditis.

The etiology of spinal adhesive arachnoiditis can be divided into six groups (1) agents injected into the subarachnoid space (2) infection, (3) trauma, (4) space-occupying lesions (5) intrathecal haemorrhage and (6) idiopathic (RANSFORD & HARRIES)

The local postoperative deformations have a traumatic origin possibly caused by mechanic or local vascular factors The adhesive arachnoiditis in the most caudal part of the cul de sac, seems to be caused by the injected foreign material thus having another pathogenesis than the postoperative deformation the high osmolarity of the compounds or other toxic effects of the contrast media might play an important role in producing the arachnoiditis in the cul de sac

Operation on the lumbar spine following myelography increases the risk of arachnoiditis (IRSTAM & ROSENCRANTZ) In the present Kontrast U material, the frequency of arachnoiditis was higher in those patients operated before repeat myelography than in those not operated upon however the difference was smaller than in the series of IRSTAM & ROSENCRANTZ Also in the material of AHLGREN (1973) the frequency of arachnoiditis was higher among the operated re investigated patients than in those not operated upon (Table 7) No explanation can be offered for this difference the disc herniation as such might influence the later development of arachnoiditis but cannot by itself explain the high incidence of post operative arachnoiditis microvascular traumatization of the arachnoid at operation might be a contributing factor

A short interval between myelography and surgery has been considered to increase the risk of later development of arachnoiditis Our Kontrast U material was analyzed in this respect but produced no evidence in support of this theory

The result of the present investigation and that of IRSTAM & ROSENCRANTZ are in many respects similar In Table 7 the results have been compiled and compared with recent reports by AHLGREN (1972 1973) He treated his results statistically in a way differing from that used in the two Swedish materials Table 7 presents the extracted true two first examinations of AHLGREN s material, thus making the different materials statistically comparable By treating his material in this way no statistical difference between the recalculated figures and those of the original material was encountered

In the Swedish series i e the present report and that of IRSTAM & ROSENCRANTZ the frequency of arachnoiditis is high following Kontrast U after Conray 60 or Dimer X the corresponding figures are low In the Danish series of AHLGREN arachnoiditis appeared more often after Conray 60 or Dimer X than after Kontrast U

The differences in frequency of arachnoiditis of the Swedish series and the Danish both absolute and relative between the different groups are evident The factors responsible for these differences are not clear

The main criteria of adhesive arachnoiditis seem to be the same in the Danish and the two Swedish series In the Swedish materials postoperative local deformations were not interpreted as adhesive arachnoiditis for reasons mentioned, while it is not clear whether such postoperative changes were included by AHLGREN The methiodal contrast medium used in Denmark was chemically identical with that in the two Swedish series but was from a different factory in the Danish series procaine was used as spinal anaesthetic, while lidocaine was used in the Swedish Ten to 18 ml of methiodal were used in the Danish examinations and 10 to 12 ml in the Swedish

The Conray 60 and Dimer X products used in the different series were from the same batches Four ml Conray 60 were diluted in 4 ml of CSF the total amount was injected i e 1 120 mg of iodine in a concentration of 140 mg I/ml In the series of IRSTAM & ROSENCRANTZ 5 ml of the medium were diluted in 2 to 4 ml of CSF and as a rule the whole amount was injected the corresponding total amount of iodine used was 1 400 mg in a concentration of 155 to 200 mg I/ml AHLGREN used an individual dosage but generally 7 5 ml of Conray 60 mixed with 2 5 ml of CSF the amount of iodine was up to 2 100 mg at a concentration of 210 mg I/ml GONSETTE (1971) suggested a maximum amount of 5 ml Conray 60 (280 mg I/ml) for lumbar myelography this limit was based on acute toxicity investigations in guinea pigs and clinical experience in man No reports in the literature dealing with possible leptomeningeal changes following myelography with different amounts of this medium have been traced

Theoretically a possible explanation of the different frequencies of arachnoiditis in the two Swedish and the Danish materials might be that AHLGREN used a larger dose of Conray 60 and Dimer X i e a dose toxic enough to cause a higher frequency of arachnoiditis However this theory cannot be applied on the Kontrast U series where a high dose of the medium in AHLGREN s series resulted in a lower frequency of arachnoiditis than in the Swedish series using a smaller dose of Kontrast U

The positioning technique in the different methiodal groups was mainly the same However the Danish Conray 60 and Dimer X patients were examined sitting while the majority of the patients in the Swedish series were examined lying After the examination the Danish and the Swedish patients were treated in the same way AHLGREN like IRSTAM & ROSENCRANTZ pointed out that arachnoiditis was never observed earlier than after 30 days Therefore AHLGREN excluded all patients with repeat myelography earlier than 30 days after the first examination In the present material few cases were examined earlier than 30 days after primary myelography exclusion of these early cases would cause no evident change in the frequencies of arachnoiditis in the different groups

Thus no uniform explanation can be offered for the remarkable difference

of the series of AHLGREN on one hand, of IRSTAM & ROSENCRANTZ and of the present material on the other Possible differences of interpretation of the different materials might offer at least some explanation of the denoted differences other factors might be different amounts of contrast medium used and different drugs used for spinal anaesthesia

In a short unpublished series of myelography with Kontrast U Conray 60 and Dimer X, CRONQVIST (1972 1973) found the frequencies of arachnoiditis to be similar to those in the two other Swedish materials

HALABURT & LESTER (1973) proposed a connection between high protein content of CSF and later arachnoiditis AHLGREN (1973) found no such correlation In the present series no analyses were performed of the CSF however in the series of IRSTAM & ROSENCRANTZ protein analyses were performed in most cases The protein content was correlated with later occurring arachnoiditis but no correlation was found

SUMMARY

Adhesive arachnoiditis was much more common after myelography with Kontrast U than after myelography with Conray 60 Surgery following Kontrast U myelography raised the incidence of later adhesive arachnoiditis this was not observed following Conray 60 The results indicate that patients already having adhesive arachnoiditis should not be further examined with lumbar myelography except for exclusive indications and then never with Kontrast U

ZUSAMMENFASSUNG

Eine adhäsive Arachnoiditis war wesentlich häufiger nach Myelographie mit Kontrast U als nach Myelographie mit Conray 60 Chirurgie nach einer Kontrast U Myelographie erhöhte das Vorkommen einer späteren adhäsiven Arachnoiditis eine solche wurde nicht nach Conray 60 beobachtet Die Ergebnisse deuten darauf hin, dass Patienten die bereits eine adhäsive Arachnoiditis haben nicht durch lumbale Myelographie untersucht werden sollten mit Ausnahme besonderer Indikationen und dann niemals mit Kontrast U

RÉSUMÉ

L arachnoidite adhésive est beaucoup plus fréquente après myélographie avec le Kontrast U qu après myélographie avec le Conray 60 L intervention chirurgicale après myélographie au Kontrast U augmente la fréquence d une arachnoidite adhésive tardive Ceci n a pas été observé après Conray 60 Ces résultats montrent que les patients ayant déjà une arachnoidite adhésive ne devraient pas être examinés par myélographie lombaire sauf pour des indications impératives et dans ce cas jamais avec le Kontrast U

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ORBITAL PHLEBOGRAPHY

I Technique

JAN BRISMAR

Conventional skull examination and carotid angiography are generally the only roentgenologic procedures used to demonstrate lesions of the orbit In most cases, however these two methods are insufficient and complementary diagnostic procedures are needed Orbitography with positive or negative contrast medium may give valuable diagnostic information (LOMBARDI 1957 BEISNER 1969 BERTELSEN 1962) but they are not easy to handle (LOMBARDI 1972) and the results may be difficult to interpret Furthermore serious complications have been described from orbitography with positive medium (HANSEN 1956 LOMBARDI 1972) as well as with gas (GARCIN & DAVID 1966 LOMBARDI 1967)

In addition none of the methods will directly demonstrate the intraorbital veins Some of the important intraorbital disorders are primarily venous i e malformations (ARON ROSA et coll 1966 LLOYD et coll 1971) or venous thrombosis (ARON ROSA et coll 1966 HAYE et coll 1970) and are therefore best demonstrated by phlebography

The superior ophthalmic vein has a more constant course than the intraorbital arteries (VIGNAUD et coll 1972) A possible displacement caused by a

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localized intraorbital mass should thus be easier to disclose by phlebography than by carotid angiography

Orbital phlebography thus appears to be the method of choice for evaluation of intraorbital disorders It was, in fact introduced as early as 1951 by DEJEAN & BOUDET and its diagnostic value has been stressed by HANAFEE (1972) and LOMBARDI (1972) among others However orbital phlebography appears not to be generally employed

The purpose of the present investigation has been to develop orbital phlebography into a simple and reliable routine method that may be used in any radiologic department and not requiring any special equipment

Review of the literature

By injecting contrast medium through a cannula in the surgically exposed angular vein DEJEAN & BOUDET (1951) obtained a filling of the ipsilateral superior ophthalmic vein and thereby demonstrated intraorbital varicose veins in a patient with unilateral exophthalmus During the following few years single pathologic cases were presented (DEJEAN et coll 1953 a b BETOULIERES et coll 1953) and in a monograph (1953) BOUDET summarized their experiences The method was soon adopted by FISCHGOLD et coll (1953) who also demonstrated that the cavernous sinus could be examined by the same technique (BREGEAT et coll 1952) In a monograph on unilateral exophthalmus, YASARGIL (1957) reported that the angular vein could be percutaneously punctured He also mentioned that if this puncture failed a frontal vein could be used instead Relatively extensive clinical materials using the angular approach were reported by ARSENI et coll (1965) and by ARON ROSA et coll (1966)

Since orbital phlebography via the angular vein in most cases includes a surgical procedure with ligation of the angular vein at the end of the examination the procedure never gained widespread use and alternative methods not requiring the presence of an ophthalmologic surgeon were developed

A method of catheterization of the anterior facial vein was introduced by BROVKINA (1964) and was employed in a material of 50 patients with possible intraorbital tumors A method primarily intended for demonstration of the glomus jugulare retrograde jugulography was presented by GEJROT & LINDBOM (1960) but an uneven and scanty filling of the cavernous sinuses was also obtained This technique was modified by HANAFEE et coll (1965) to include bilateral catheterization of the inferior petrosal sinuses This modification gave a more constant filling of the cavernous sinuses and also of the intraorbital veins (RAND & HANAFEE 1967 SHIU et coll 1968) The latter authors reported some complications One patient developed a partial lateral medullary syndrome

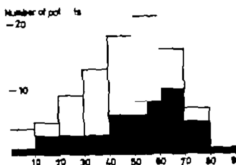


Fig 1 Age and sex distribution of the series □ males ■ females

presumably due to rupture of one of the pontine veins and in two patients contrast medium extravasated from the inferior petrosal sinus to the extradural space TAKAHASHI & TANAKA (1971) demonstrated that the inferior petrosal sinuses could be catheterized via the femoral vein

Orbital phlebography may be performed after injection into the frontal veins (YAŞARGIL 1957) This method was later used by VRITSIOS (1961) who advocated this approach as the method of choice NEUBAUER & SUBBE (1966) normally using the angular vein puncture, mentioned that they on one occasion in a nervous patient successfully tried frontal vein puncture In a later article SUBBE & KUNITSCH (1966) described a technique of percutaneous puncture of the frontal vein and demonstrated that the flow of the contrast medium may be directed by applying digital compression of the superficial facial veins A major advantage with the frontal approach is that the veins of both orbits are simultaneously filled

Most authors have used a scalp vein needle for the puncture but VIGNAUD & CLAY (1969) used a percutaneous teflon cannula and PISCOL (1970) advocated the use of percutaneous catheterization of a frontal vein The angular approach however has still been preferred by some authors (SCHOBER & BENDER 1968 MCNULTY 1969)

Material

The material consists of 101 orbital phlebographies in 94 patients examined via the frontal approach up to September 1973 About 90 have been performed by the author and all except 10 since January 1972 All patients had symptoms or signs possibly related to either one or both orbits the cavernous sinuses or the basal sinuses of the skull The age and sex distribution of the material appear in Fig 1 The youngest patient was a girl one day old, born with unilateral ex

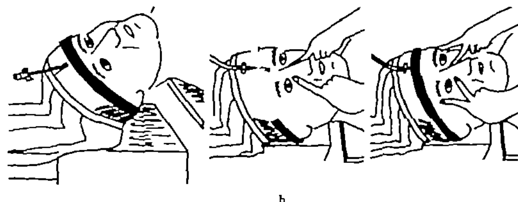


Fig 2) Position of patient for puncture with hanging head and tourniquet for enous stasis b) Patient is compressing the anterior facial veins Position of the tourniquet has been changed towards the periphery) Patient compressing also the supraorbital veins

ophthalmus the oldest was an 81 year-old woman with possible intraorbital tumor Two patients below the age of one year have been examined

Technique

Usually no preparation of the patient is needed Several examinations were performed on an out patient basis In a few cases 5 to 10 mg Diazepam (Valium Roche) was given intravenously or orally before the examination General anaesthesia was used in children

Puncturing technique The patient is placed supine on the same examination table as for cerebral angiography with the head on the automatic film changer The couch is elevated so that the neck is extended and the head is somewhat lower than the rest of the body (Fig 2 a) The hair of the patient is covered by a sterile cloth fixed by surgical tape to the forehead and a tourniquet is placed around the head just above the supraorbital ridge, to produce venous stasis In the first few cases of this series, a scalp vein needle was used for the puncture Often however the examination was unsuccessful, either because of failure to puncture the vein or because of perivascular leakage during the injection In a previous investigation (BRISMAR & GOTHLIN 1972) phlebographies of the foot were performed via standard disposable teflon cannulas with a metal mandrin for percutaneous puncture (Viggo Venflon 140) These cannulas were also used for the remaining orbital phlebographies

After a thorough cleansing of the skin of the forehead a frontal vein is localized This is facilitated by a spotlight directed almost tangential to the forehead



Fig 3 A p ses before p- plication of compre sion to demonstrate the anatomy of the facial eins nd plan the digital compression Cannula in frontal ein (→) Supra orbital eins (↔→) Angula and anterior facial eins (→→) Superior ophthalmic eins (○→)

In some cases a vein can be palpated although it may not be seen The vein is punctured as high up in the forehead as possible The mandrin is then with drawn and the cannula further advanced until the tip is about one cm above the eyebrows

If no vein can be localized a blind puncture should be tried as high up in the forehead as possible about one cm lateral to the midline The cannula is then advanced—w thout waiting for blood to appear in it—down towards the root of the nose and the mandrin withdrawn The cannula is then slow ly withdrawn and when blood appears advanced into the vein to a safe intraluminal position If no blood flow is obtained the cannula and mandrin, after careful inspection of the cannula to disclose any damage to its tip are remounted and a new puncture tried In most cases even a blind puncture is successful using this tech nique When the cannula is safely positioned in the vein the tourniquet is removed

Exposure technique A serial cut film changer was used in all cases One film was exposed before injection of the contrast medium for subtraction Immediately after this the injection was started and 1 to 1 5 seconds after the first film four films were exposed at 1 second intervals The same series was u ed for all pro jections



Fig 4) Tourniquet in the ordinary position Collaterals normally passing over the mid line t th root of the nose are this case nderdev l oped and no contrast medium passes to the left orbit b) After removal of the tourn quet ontrast medium passes t th left orbit in a frontal em previously occluded by the tourniquet (→)

The contrast medium (Isopaque cerebral Nyegaard) was manually injected using a connecting tube between the syringe and the venous cannula to decrease the radiation dose to the examiner In some cases for examination of the cav ernous sinuses, 20 ml of contrast medium were used for the axial view other wise for all projections 10 ml were injected in about one second

In most patients, 5 to 6 different projections were used

(*1*) A p projection without compression the beam angulated slightly from below Most of the face was included in the view (Fig 3) This series was re viewed before the examination was continued to judge the catheter position and the arrangement of the veins of the forehead

To obtain bilateral filling of the intraorbital veins and the cavernous sinus the facial veins had to be compressed in order to direct the flow of the contrast medium into the orbits Information concerning the venous anatomy of the forehead obtained from series (1) proved valuable when deciding how the compression should be applied





b

Fig 5) Digital compression is applied too high on the right side and obstructs the flow of contrast medium to the right orbit b) The digital compression now correctly applied with bilateral filling of the intra orbital veins

The tourniquet was reapplied this time above the catheter tip to occlude the veins of the forehead In a few cases it was necessary to avoid compression of those veins to allow passage of contrast medium over the midline to the contra lateral orbit (Fig 4) In addition the patient was instructed to apply digital compression on the anterior facial veins by firmly pressing his index fingers to the infra-orbital ridge close to his nose (Fig 2 b) It is important to avoid applying the compression too high up as this may interfere with the filling of the intraorbital veins (Fig 5) In some cases also the supraorbital veins had to be compressed This was achieved by having the patient press his index fingers towards the lateral part of his eyebrows while his third fingers compressed the anterior facial veins (Fig 2 c)

During this compression the following series were exposed

(2) A p view angulated 10 degrees from below (Fig 6 a)

(3) Semi axial view angulated 40 degrees from below (Fig 6 c) with the teeth projected slightly below the cavernous sinus

(4) Axial view (Fig 6 e)

(5) Straight lateral view (Fig 6 b)

(6) Oblique lateral view with one orbit projected above (not in front of) the other (Fig 6 d) This view allowed separation of the veins of the two orbits and as important in many cases, separated the orbital veins from the lateral parts of the supraorbital veins

Subtraction films were reviewed before the examination was considered completed If these films were not satisfactory injection of contrast medium and serial exposure were repeated

Results

Unsuccessful puncture attempts have during this series decreased from a fairly high percentage down to a few per cent (one failure in the last 40 patients)

The intraorbital veins were sometimes much better filled in one orbit than in the other In order to establish the frequency of unilaterally unsatisfactory examinations the results have been classified for each orbit separately into one of the following categories

I Superior ophthalmic vein only incompletely demonstrated

II Superior ophthalmic vein demonstrated in its entire course to the cavernous sinus but only few other veins

III Superior ophthalmic vein demonstrated to the cavernous sinus, and several other intraorbital veins

A bilaterally satisfactory examination of the intraorbital veins (group III) almost always implies a diagnostic demonstration of the cavernous sinuses and adjacent basal sinuses

During the first part of this series the examinations were not infrequently classified as unsatisfactory or merely acceptable (groups I and II) while during the latter part almost all examinations have been classified as belonging to group III (Fig 7) The most important reasons for this improvement are the substitution of the teflon cannula for the scalp vein needle, and the fact that more care has been given successively to the digital compression

Complications During injection of contrast medium the patient has a sensation of tension in the forehead or intraorbitally This sensation disappeared in a few seconds and was seldom really painful After repeat puncture attempts a





b





d



Fig 6 Projections ed) A p iew b) Lateral view) Semi xial iew d) Oblique lateral iew with one orb projected abov (not in fron of) the other) Axial iew

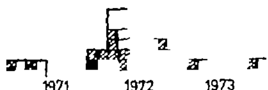


Fig. 7. Examinations performed during 1971 to 1973. The number of satisfactory examinations is initially low but rises markedly towards the latter part of the series.
□□ one patient in orbita
□ satisfactory examination
▨ acceptable examination
■ unsatisfactory examination

hematoma sometimes developed in the forehead. In other cases, due to rupture of small veins in the forehead, the medium was injected partly perivascularly. Some patients mentioned difficulties in breathing through the nose during a short period of time after each injection of the medium, probably due to a transient swelling of the nasal mucosa. In fact, an accumulation of medium in the nasal mucosa is frequently observed. No other side effects or complication have been encountered in this series.

Discussion

In a review of orbital phlebography PISCOL et coll. (1970) estimated the total number of pathologic findings in the literature to be approximately 260 cases. The introduction of the transcutaneous frontal vein approach has made orbital phlebography much simpler since no surgical assistance is needed, and the examination can be performed on out-patients. As a consequence, the number of reports on orbital phlebography has increased considerably during the last few years (e.g. LOMBARDI & PASSERINI 1968, 1969, TAKAKU & SUZUKI 1969, LLOYD 1970, 1972, CRISTOBAL & DEL RIO CABAÑA 1972, RUSSELL & MILLER 1972). Even authors who earlier advocated other techniques, now prefer the frontal approach (HANAFEE et coll. 1968, ARON ROSA et coll. 1970).

Though much simpler to perform after the introduction of frontal vein puncture, the method has not gained widespread use, essentially due to technical difficulties still existing (e.g. BEISNER 1969, CASTREN et coll. 1971). HANAFEE et coll. (1968) reported only 50 per cent success in attempting the frontal vein puncture while LOMBARDI & PASSERINI (1968) were successful in 88 per cent of their cases.

HANAFEE (1972) stresses the importance of not jumping into the conclusion of superior ophthalmic vein obstruction as lack of filling of the posterior aspects of the superior ophthalmic vein may be a purely technical result or may be related to an increased flow phenomenon If however the compression of the facial veins has been effective the injection rapid and well developed veins connect the injection site with the orbits, there should normally be a complete filling of the superior ophthalmic vein all the way back to the cavernous sinus In previous reports compression devices have been presented developed to facilitate the venous puncture by compressing the jugular veins (TENNER & TROKEL 1970 LEE & LIN 1971) or to direct the injected contrast medium to the intraorbital veins (HAYE et coll 1970) No compression device except for the tourniquet has been used in the present series The tourniquet in combination with digital compression applied by the patient and a rapid injection of contrast medium has proved effective enough to produce countercurrent filling of the intraorbital veins also in two cases with fistula between the carotid artery and the cavernous sinus

Other techniques than the one described in this report (angular vein puncture inferior petrosal sinus catheterization and even frontal vein puncture with a scalp vein needle) in most cases give results that at best can be classified as acceptable (group II) Such a result may allow diagnosis of disorders affecting the superior ophthalmic vein though even in such cases valuable information may be lost as the small intraorbital veins are only incompletely filled Changes of the small veins may in some cases be decisive for a correct diagnosis

Five films were exposed in each projection However only in a few cases did the last two films offer any additional information Thus it seems possible to reduce the dose of radiation by exposing only three films in each projection one film before injection of the contrast medium and after a pause of 1 to 1 5 s two films at an interval of 1 s The first series performed without compression is used to control the position of the cannula and to give a survey of the veins of the forehead and may be replaced by a single film exposed at the end of the injection of the medium The total number of films for the six projections is thus reduced from 30 to 16 Even without an automatic film changer and without subtraction valuable information concerning intraorbital pathology may be obtained

As no complications have been reported using the frontal vein approach and as the examination can be performed on an out patient basis it is suggested that orbital phlebography should be the first radiologic procedure after conventional skull examination in the investigation of intraorbital disorders The results gained with the present method will be presented in forthcoming reports

SUMMARY

Different techniques for orbital phlebography are reviewed and the author s method is described in detail Experiences with this method in material of 101 orbital phlebo graphies are presented

ZUSAMMENFASSUNG

Die erschiedenen Methoden f die orbitale Phlebographie werden durchgegangen und die Methode des Verfassers im einzelnen beschrieben Erfahrungen mit dieser Methode an einem Material on 101 orbit len Phlebographien werden orgestellt

RÉSUMÉ

L auteur passe en revue differentes techniques d phlebographie orbitaire et decrit en detail sa methode personnell Il present les esultats de cett methode sur une seri de 101 phlebographies orbitaires

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PEDUNCULATED TUMOURS OF THE OESOPHAGUS

Two cases of lipoma

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Benign as compared with malignant lesions of the oesophagus are usually described as rare. To consider benign tumours of the oesophagus as in themselves uncommon is however probably inaccurate as those recorded in the literature during the last few decades far outnumber all those previously reported. The reason for this is not necessarily an increased frequency but an improvement in the diagnostic procedures, i.e. the development of radiographic and endoscopic techniques.

The early literature was reviewed by MacKenzie (1884), Minski (1895), Brehon (1903) and Goebel (1904). Adams & Hoover (1945) recorded 96 benign oesophageal tumours in the literature between the years 1912 and 1945 while Gerlach & Stegmaier (1951) found less than 200 benign lesions up to 1951. Totten et coll. (1953) reviewed 163 benign tumours and cysts of the oesophagus including all those previously mentioned. Moersch & Harrington (1944) reported a frequency of 15 benign tumours in 11 000 patients with dysphagia and Jackson & Jackson (1951) an incidence of 10 innocent growths in a series of 4 000 patients with oesophageal conditions other than those caused

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by foreign bodies As many of these neoplasms fail to give rise to clinical signs the true incidence of benign tumours is presumably higher This is illustrated in a review of 7 495 autopsies with 44 benign tumours of the oesophagus (MOERSCH & HARRINGTON) SCHAFER & KITTLE (1947) reported 11 benign tumours in 6 001 autopsies The comparatively low incidence is evident from the figures by NESE (1957) who for a ten year period reported 10 benign and 182 malignant lesions carcinoma of the cardia being excluded The total number reported was estimated by PALMER (1952) to lie between 200 and 300

No commonly accepted classification of benign neoplasms of the oesophagus exists They include a great variety of conditions among which myomas and polyps dominate According to STOREY (1962) the polyps constitute about one third of all the benign growths all other varieties with the exception of the myomas being most uncommon NORA (1964) collected only 17 lipomas and lipofibromas from the literature The latter are however not true lipomas and should according to STOREY be classified as polyps this also applies with myxo fibromas, myofibromas, lipomyomas and probably pedunculated fibromas True lipomas are extremely rare (TERRACOOL & SWEET 1958)

Benign oesophageal tumours may also be groped by their macroscopic fea tures and are from this point of view customarily divided into those that arise from the mucosa or the submucosa and those originating deep to these layers They are known as intra-oesophageal or mucosal and intramural or extramucosal tumours respectively The mucosal tumours is frequently pedunculated and appears as an intraluminally situated mass It is usually referred to as a polyp although lipomas fibromas and occasionally myomas and also other rare lesions may appear in a pedunculated form Malignant tumours such as leiomyosarcomas and especially carcinosarcomas sometimes occur with more or less of a pedicle malignant changes in a large originally benign tumour have also been reported The size of a pedunculated tumour may be very large and the mass may fill the whole lumen of the oesophagus Most take their origin from the uppermost part of the oesophagus or the adjacent regions of the hypopharynx as many as 25 of 40 polyps have been reported as attached at the level of the cricoid cartilage (TOTTEN et coll) Mucosal tumours can also be sessile in shape and protrude into the lumen of the oesophagus

Large intraluminal pedunculated tumours give rise to special diagnostic problems clinical as well as roentgenologic GLYNN (1940) collected 16 cases of large pedunculated tumours among which were 4 lipomas SAMSON & ZEIMAN (1942) accounted for 26 large pedunculated tumours and BERNATZ et coll (1958) added 2 more TANEW (1947) reported 13 grossly (over 7 cm) pedunculated tumours that had all been examined roentgenologically among these there were 3 possibly 4 malignant lesions but no lipoma



Fig 1 Case 1 Huge intraluminal tumour [wi]th pedicle and well demarcated lo[wer] pole abo[ve] the cardia

It is apparent from a perusal of the literature that the patients often failed to present any characteristic clinical signs although most of them complained of some degree of dysphagia This may however be absent and in any event is not diagnostic of a benign intraluminal growth The sudden appearance of a mass in the mouth is a fairly frequent single sign It is noteworthy that the presence of even a huge intraluminal tumour may escape detection roentgenologically as well as at endoscopy cardiospasm or achalasia cardiae often being the preliminary diagnosis and also sometimes the final one It seems that especially the large variety of pedunculated tumours often are difficult to detect endoscopically even when an intraluminal mass has been demonstrated roentgenologically This is important from a surgical point of view as these tumours may usually be removed with a permanent restoration of function Failure to recognize the true nature of the lesion has on several occasions led to a disastrous outcome

Case reports

Case 1 Man aged 58 years who for one year had had difficulty in swallowing solid food and a feeling of a lump in the throat The first roentgen examination revealed a dilated oesophagus containing food The stomach colon kidneys and chest were normal A diagnosis of achalasia was made Endoscopy failed to disclose any abnormality An ESR of 126 and



Fig 2 Case 2 Tumour appearing in the mouth

anaemia were present After some months the difficulty in swallowing increased and again anaemia as well as a high ESR were recorded Further roentgen examination of the oesophagus produced the same result as previously An operation on the cardia relieved the symptoms

Five months later a third roentgen examination demonstrated increased widening of the oesophagus but nothing else endoscopy now however disclosed a smooth defect A well defined mass occupying nearly the whole of the oesophagus was evident in the next roentgen examination It diminished in size cranially and a long pedicle was present superiorly The lower pole of the lesion rounded and well demarcated lay immediately above the cardia (Fig 1) A third endoscopic examination was negative but when repeated revealed the tumour pedunculated and covered with normal mucosa the latter confirmed by biopsy

The tumour was removed only with difficulty by cervical oesophagotomy It was 25 cm length and 8 to 10 cm in diameter at its lower end it was attached to the upper part of the oesophagus by a thin pedicle

Pathology A fusiform mass furnished with a pedicle soft and homogeneous in consistency with greyish red cut surface It was composed of fat tissue interwoven by coarse bundles of connective tissue with some vessels The surface was covered with normal epithelium and the mucosa was partly ulcerated No signs of malignancy Diagnosis Lipoma rich in vessels and partly converted into fibrous tissue

Case 2 Man aged 83 years who for several years had noticed a lump in his throat which he now and then could make to appear in his mouth The lump had increased in size during the last few years and difficulty in swallowing solid food had arisen but there had been no trouble with liquids When seen the patient had a lump protruding 10 cm from his mouth (Fig 2) Roentgen examination disclosed a large elongated tumour in the hypopharynx and the oesophagus partly deforming the left piriform sinus (Fig 3) The pedicle was excised and a mass 4 to 5 cm in diameter and 15 cm in length removed

Pathology A lobulated lipoma banana shaped and with a pedicle apparently benign Microscopy revealed highly differentiated fat tissue covered with normal mucosa

The patient died in his sleep two days after the operation Autopsy disclosed a further polypoid mass the size of a hen's egg and furnished with a pedicle attached to the region of the right aryepiglottic fold



Fig 3 Case 2 Large elongated tumour in the oesophagus arising from the left piriform fossa

Discussion

The features of the two cases include most of those important in pedunculated tumours of the oesophagus A total of 160 such tumours have been reported

The age distribution may be compared with that of 81 leiomyomas published by STOREY About 75 per cent of these appeared before the age of 50 and 96 per cent before the age of 60 years compared with 45 5 and 66 4 per cent respectively of 132 pedunculated mucosal tumours previously reported An explanation of the difference may be that it takes longer for a pedunculated tumour to give rise to symptoms that take a patient to a doctor Many of the tumours also reached a fair size before the final diagnosis was made

Eighty two of the 115 benign tumours occurred in men (71 3 per cent) and 33 in women (28 5 per cent) The figures for the leiomyomas are 65 and 35 per cent respectively (STOREY) Both pedunculated tumours and leiomyomas thus occur predominantly in men and in a ratio of about 2 5 to one This difference is not so striking as that in malignant oesophageal tumours roughly 80 per cent of which arise in men

Of the 160 cases previously reported and the 2 cases now added, 136 consisted of benign and 26 of malignant conditions The number of lipomas were 23 and together with the lipofibromas and a single case of myxolipoma constitute a fair portion of the pedunculated tumours (22 2 per cent) There were 11 fibromas and 7 myomas among the 162 cases, in 73 of which polyps including myxofibromas and fibromyomas predominate Malignant tumours occurred in 26 patients and included carcinosarcomas and sarcomas equally distributed Two of the 26 malignant growths were carcinomas a sarcoma sometimes arose in a previously benign lesion

Lipomas are more frequent in men than in women, the relative frequencies being 18 4 and 7 5 per cent respectively When the lipofibromas and the single myxolipoma are included among the lipomas the figures become 29 3 and 10 0 per cent respectively The polyps occur in 47 5 per cent of men as well as in women, the fibromas having a reverse distribution with the figures of 5 5 per cent for men and 15 0 per cent for women no comments upon this reversal have apparently been made

No difference in the distribution of malignant tumours between men and women appears to exist as 17 5 per cent of the pedunculated tumours were malignant in both men and women Eight carcinosarcomas occurred in men and only 2 in women

It is stated in the literature that benign pedunculated oesophageal neoplasms usually arise from the upper part of the oesophagus, often at the level of the cricoid cartilage The attachment of the pedicle was given in 116 cases

Benign pedunculated tumours issued from the upper part of the oesophagus including the level of the cricoid cartilage in 73 cases (87 9 per cent) in only 10 did the pedicle arise in the lower third and in 9 cases in the middle part of the oesophagus Lesions with a stalk from the lower third of the oesophagus were polyps and myomas and a single cystic condition No lipoma or fibroma arose from this region These findings are the reverse of those reported in malignant pedunculated tumours which predominantly were attached at the lower or middle part of the oesophagus (66 0 per cent) A malignant tumour was attached with a pedicle at the upper part of the oesophagus however in 7 cases It may perhaps be stated that the demonstration of a pedicle attached at the uppermost part of the oesophagus strongly favours the presence of a benign intraluminal tumour

Seventy six of the benign tumours were over 7 cm, many of them more than 20 cm in length 21 were under 7 cm Among the lipomas and fibromas a length of more than 7 cm dominated 36 being larger and only 6 under 7 cm On the other hand one third of the polyps were under 7 cm Some of the largest tumours were however polyps The large variety were also the more common among the

malignant growths The size of the tumour thus seems not to play the same part as the attachment of the pedicle in reaching a correct diagnosis

Seventy two of the 162 cases were examined roentgenologically The size of the tumour was over 7 cm in 45 cases, under 7 cm in 16 cases and unknown in 11 cases

Nine cases with the roentgenologic diagnosis of achalasia were among those with growths over 7 cm Three of these were cases of lipomas (MOERSCH & HARRINGTON BAUMANN & VON HASSELBACH and Case 2 in this report) 2 were of fibromas (HAENISCH 1924 1938 and FAHR 1923) 3 of polyps (McBRIDE 1951 BERNATZ et coll and JOHANSSON & SILANDER 1963) and 1 of myxofibroma (MOERSCH & HARRINGTON) The tumour always issued with a stalk from the upper third of the oesophagus The same diagnosis was reached by endoscopy in 3 of them 2 polyps and 1 lipoma but in 6 cases this examination was negative A second roentgen examination in 2 cases revealed an intraluminal tumour and in a further 3 cases a mass was evident in a second endoscopic examination in one of the latter although a second roentgen examination demonstrated a dilated oesophagus with filling defects, a diagnosis of cardiospasm was made

Endoscopy produced a diagnosis of cardiospasm in one case (SERFLINO & BAUDITZ 1953) Subsequent examination disclosed an intraluminal tumour at first considered to be a fibroma but finally diagnosed as a fibromyosarcoma

The 7 cases with the final roentgen diagnosis of achalasia had sausage shaped tumours between 13 and over 20 cm in length usually reaching the cardia or the lower part of the oesophagus In only 3 of these cases were filling defects observed (HAENISCH McBRIDE and BERNATZ et coll) In 2 cases with the diagnosis of achalasia the tumour was identified at a subsequent roentgen examination the mass was very large and reached the region of the cardia In one of these cases (BAUMANN & VON HASSELBACH) the oesophascope could not be passed into the oesophagus as it was obstructed at the entrance by a supposedly stenotic lesion Repeat oesophagoscopy disclosed an intraluminal mass in 3 of the other 7 cases (MOERSCH & HARRINGTON 2 cases and BERNATZ et coll) A final diagnosis of achalasia or cardiospasm was thus made in 4 of the original 9 cases Cardioplasty was performed in 4 cases and in 3 of these no tumour was evident In one of them gastrotomy was later carried out a mass was seen through the cardia but not removed Only a third operation and subsequent section disclosed the presence of 3 very large polyps (McBRIDE) The other 2 cases in which cardioplasty was performed also went to section and the tumour was revealed (HAENISCH FAHR)

A diagnosis of achalasia cardiae or cardiospasm was never made either roentgenologically or endoscopically in tumours under 7 cm

A roentgenologic diagnosis of cardiospasm was made in 2 out of 11 cases harbouring a tumour of unknown size (BERNATZ et coll) The report concerning these 2 cases is scanty Oesophagoscopy disclosed a stalked tumour (polyp) in both these cases, in which a mass was said to have appeared in the mouth The roentgenologic report was nevertheless cardiospasm JOHANSSON & SILANDER (1963) reported probable malignancy in a case at roentgen examination but a benign polyp was identified endoscopically and subsequently removed

Conclusion

The roentgenologic changes in benign oesophageal tumours differ from those caused by malignant lesions The signs of benign intramural lesions have been described by several authorities (SCHATZKI & HAWES 1942 HARPER & TISCENCO 1945) and large tumours in some detail by others (TAMIYA 1927 PALUGYAY 1932 HAENISCH 1924 1938) Double contrast examinations (PALUGYAY 1932) and recently transversal tomography (GOCKEL 1959) have been used to define the relationship between the tumour and the oesophageal wall The demonstration of a mass within the oesophageal lumen is possible with the conventional technique with barium sulphate as the medium One sign is of special value The mucosa of the tumour as well as that of the oesophageal wall are usually quite normal although the folds are flattened or have disappeared due to dilatation of the oesophagus harbouring a large intraluminal mass The surface of the latter may be grossly irregular due to its more or less lobulated shape giving the impression that it is divided into two or more separate entities the benign tumours are sometimes multiple although a single lobulated growth is more common No real obstruction to the contrast medium is usually encountered even when the tumour is of huge size The growth is seen to be surrounded by a strip of contrast medium when examined in different positions and with rotation of the patient the lower pole is usually well demarcated

The pedicle may be difficult to demonstrate and has been sometimes impossible even when the true nature of the lesion was known to the examiner beforehand

Misinterpretation of the condition as being due to cardiospasm may perhaps be avoided if the possibility of a large benign tumour be borne in mind Negative endoscopy even with a negative biopsy may fail to eliminate a large benign intra oesophageal tumour It is possible to pass an oesophagoscope down the oesophagus in the presence of such a growth without detecting its presence Furthermore, biopsy may prove negative as the mucous membrane covering the tumour is usually normal

SUMMARY

A review of the symptoms and clinical signs in 160 pedunculated tumours of the oesophagus recorded in the literature and two recent cases has indicated that such growths are mainly benign in nature and are polyps. lipomas and fibromas are rare. The possibility of excluding malignancy is discussed. Achalasia cardiae appears to be a common misinterpretation of the signs observed at roentgen and endoscopy examinations.

ZUSAMMENFASSUNG

Aus der Literatur wurden 160 Fälle von gestielten Tumoren des Oesophagus gesammelt. Nach Beobachtung von zwei eigenen Fällen wurde das Gesamtmaterial auf diagnostische Zeichen und klinische Symptome überprüft. Es konnte festgestellt werden, dass es sich im allgemeinen um gutartige Polypen handelt, selten lagen Lipome oder Fibrome vor. Die Möglichkeit einer Malignität muss in Frage gestellt werden. In der Praxis wird oft trotz Röntgenuntersuchung und Endoskopie irrtümlicherweise Cardiospasmus diagnostiziert.

RÉSUMÉ

L'analyse des symptomes et des signes cliniques dans 160 tumeurs pédiculées de l'oesophage publiées dans la littérature et deux cas récents ont montré que ces tumeurs sont le plus souvent de nature bénigne et sont des polypes; les lipomes et les fibromes sont rares. L'auteur examine la possibilité d'exclure le diagnostic de malignité. L'achalasie du cardia paraît être une erreur d'interprétation fréquente des signes observés à l'examen radiologique et endoscopique de ces tumeurs.

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ANGIOGRAPHY IN RENAL AMYLOIDOSIS

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No reports on the angiographic appearances in amyloidosis of the kidney seem to have appeared so far. This is perhaps surprising, since amyloidosis is not uncommon and is an etiologic entity in the nephrotic syndrome and may eventually lead to renal failure (HAMBURGER et coll. 1968, BROD 1973). Six patients with histologically confirmed amyloidosis of the kidneys have been examined and the angiographic appearances, some marked with progression of the disease, are now presented.

Material and Methods. The material consisted of 6 patients, 2 males and 4 females, aged from 21 to 65 years. Two of these had primary amyloidosis, 3 had amyloidosis secondary to rheumatoid arthritis and one patient had developed amyloidosis secondary to osteomyelitis.

All the patients were examined by transfemoral aortography and bilateral selective nephroangiography. The latter was performed with 4 to 10 ml contrast medium (Isopaque Coronar, Nyegaard, Norway) injected into the renal artery at a suitable rate, the programme for filming usually being 2 films/s for 2 s, followed by a fifth and a sixth film at 2 s intervals. Phlebography was also performed in 2 patients to exclude renal vein thrombosis.

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Fig. 1



Fig. 2

Fig. 1. Case 1. Right selective angiography. The kidney is enlarged (14 cm × 7 cm). Narrow intrarenal arteries. Smooth stenoses and in some places dilatation of arteries in upper pole of kidney. Interlobular arteries not filled. (Contrast medium from previous pyelography in renal pelvis.)

Fig. 2. Case 2. Left selective angiograph. Intrarenal arteries narrowed, tortuous towards the periphery and in some places slightly irregular. No filling of interlobular arteries.

Attention was paid to kidney size, calibre of the main renal artery, the appearances and filling of intrarenal arteries, the width of the cortex and definition of the corticomedullary junction as well as to the renal circulation time and demonstration of the renal vein.

One of the patients, a 56-year-old woman, was admitted with acute renal failure. The remaining 5 patients also had reduced renal function, the endogenous creatinine clearances being 3 to 65 ml/min. In addition, four of these patients had a nephrotic syndrome. The diagnosis of amyloidosis was reached by renal biopsy in 3, by rectal biopsy in one patient and by autopsy in 2 patients. Five patients have died and one is still alive after an observation period of 2 1/2 years.



Fig 3 Case 3) Right selecti angiography Arteriovenous fistula econdary to renal biopsy m lower pole of kidney Narrowing of intrarenal arteries except for artery feeding the fi tula b) 17 months later Closure of arteriovenous fistula Decrease m size of kidney The calibre of the main renal rtery has diminished and the intrarenal arteries hav become more na ro ed nd tortuous

Case reports

Case 1 Woman, aged 56 admitted w th acute enal failure had had rheumatoid arthritis since the age of 23 was badly disabled and had been using wheel chair for the last t o decades During the few months before dmittance she had gastrointestinal symptoms with abdominal pain and diarrhoea She was in incipient shock with poor peripheral circulation and oliguria Angiography The kidneys were slightly enlarged The main renal arteries were of normal calibre but the intrarenal arteries were irregularly nar rowed th cortical arteries were not filled and the corticomedullary junction was indistinct The renal emptying time was prolonged phlebography excluded thrombosis f th renal ein (Fig 1) Tw days after admittance she still had oliguria with serum creatinine 11 mg % and serum potas um 7 0 mEq/l Peritoneal dialysis as instituted and continued for t day the dialysis fluid appeared normal Slight improvement as followed by worsening f her condition Laparotomy disclosed ischaemi colitis f the splenic flexur

which was resected She died a few hours later Autopsy demonstrated marked general arteriosclerosis anoxic enterocolitis and secondary amyloidosis f the kidneys myocardium spleen lungs liver pancreas and the intestines

Case 2 Woman aged 59 w th proteinuria for 14 months was admitted with marked peripheral oedema The protein loss in the urine amounted to 10 to 15 g/24 hours Biopsies of the kidney as well as of the liver revealed amyloidosis Angiography Normal sized kidneys with slight cortical reduction Th intrarenal arteries were narrowed and some what tortuous th interlobular arteries were not filled and th corticomedullary junction was indistinct (Fig 2) Renal function rapidly deteriorated from a chromium EDTA clearance of 65 ml/min to 35 ml/min in two months Chlorochin phosphate and penic l lamine were tried but no clinical effect was noticed and the patient died four months later

Autopsy confirmed the diagnosis f amyloidosis the myocardium was involved as w ll

Case 3 Woman aged 50 with rheumatoid arthritis for thirty years and with clinical signs on admission f a nephrotic syndrome the diagnosis f amyloidosis was established after biopsies from the kidney and th rectal mucosa Angiography The kidneys were of normal size the intrarenal arteries somewhat narrowed th cortical arteries not filled and th corticomedullary junction indistinct Serum creatinine 1 5 mg % and endogenous creatinine clearance 50 ml/min Treatment with azathioprine was started few weeks later and still continues She initially had proteinuria of 6 g/24 hours the albumin creatinine clearance quotient is now 0 05 $^{0}/_{00}$ i normal Renal function during the sam period of observation has slightly improved

Case 4 Man aged 65 w th arterial hypertension for twenty years and for several years lassitud and diffuse abdominal pain the serum creatinine concentration was elevated t 2 0 mg % in 1963 An examination about that time included angiography and renal biopsy Th renal specimen suggested myloidosis a diagnosis that could not be d finitely onfirmed Angiography Somewhat red ced kidney size The main renal arteries wer normal but the interlobar arteries were slightly irregular the cortical rteries were not filled and the corticomedullary junction was indistinct During the next tw years th enal function gradually decreased and in January 1966 the patient died in uraemia Autopsy revealed contracted kidneys with amyloidosis

Case 5 Woman ged 21 with rheumatoid arthritis for six years Renal biopsy was performed for nephrotic syndrome of six months duration this as well as biopsy of the rectal mucosa revealed amyloidosis Angiography of th kidney was performed about seven months after this when the patient had an endogenous creatinine clearance of 13 ml/min and the serum creatinine was 4 4 mg % Further angiography was performed 17 months later At the first angiography n rteriovenous fist la secondary t renal biopsy had been demonstrated in the lower pole of the right kidney At the second angiography the fistula had closed the kidneys were smaller and the main renal artery as w ll as the intrarenal rteries narrowed (Fig 3) Th enal function had then f rther decreased the endogenous creatinine clearance being 3 ml/min and the serum creatinine 10 2 mg % (This case is lso described n a previous report by EKELUND & LINDHOLM 1971)





Fig 4 Case 6 Contracted kidney with irregular surface) Aortic injection Narrowing of main renal artery The interlobar arteries are somewhat dilated with focal irregularities and absence of normal tapering b) Selective angiograph Dilatation of arteries as result of selective injection of contrast medium Distance between capsular artery and renal surface indicates shrinkage of the kidney) Nephrographic phase

Case 6 Man aged 46 with history of osteomyelitis of the right femur for 33 years had also had recurrent urinary infection for 5 years The patient was admitted in 1970 after period of rapid deterioration with serum creatinine of 23 mg % peritoneal dialysis was instituted Biopsy of the rectal mucosa negative in 1968 now disclosed amyloidosis Angiography Markedly contracted kidney (Fig 4) Intermittent peritoneal dialysis was continued but after about thirty treatments abdominal adhesions made further treatment impossible and the patient died in uraemia

All 6 patients thus had abnormal angiographic findings In one patient the kidneys were slightly enlarged in 2 they were normal in size and in 3 patients their size was reduced The interlobular arteries were not demonstrated and the

corticomedullary junction was indistinct in Cases 1, 2, 3 and 4. The main renal artery was normal in calibre in these cases, but the interlobar arteries were narrowed or irregular or both. Cases 5 and 6 had narrowed main renal arteries and marked cortical reduction. The renal vein was always open in two cases proved by phlebography.

Discussion

Amyloidosis may be primary or secondary but is usually secondary to chronic conditions such as osteomyelitis, polyarthritis or tuberculosis. The disease was considered primary in 2 of the present cases and secondary in 4 of the cases. The kidney together with the liver and spleen are the organs usually involved in generalised secondary amyloidosis (BRANDT et coll. 1968). From the renal aspect the disease may present itself in the form of a nephrotic syndrome as in 4 of the cases. With progression of the condition, renal insufficiency and uraemia may develop as in all the cases.

Vascular lesions are characteristic with thickening of the vessel walls, the lesions affecting not only the glomerular tufts but also vessels of any size in the renal parenchyma (COHEN 1967). These vascular changes were also reflected in the angiographic findings in the present 6 cases of amyloidosis, in which narrowing, tortuosity and irregularity of the intrarenal arteries were common. Fibrosis of interstitial tissue may lead to contracted kidneys as in 3 of the cases, this usually being a late manifestation.

One interesting feature in the material was the development of an arteriovenous fistula secondary to renal biopsy. This illustrates two important features concerning such fistulas: (1) The risk of fistula formation is increased in cases with abnormalities of renal vessels and (2) the high incidence of spontaneous closure of such fistulas (EKELUND & LINDHOLM 1971, EKELUND et coll. 1972).

BARCLAY et coll. (1960), after collecting 48 cases, considered renal vein thrombosis an important and often terminal complication of renal amyloidosis. On the other hand HELLEKANT & KAUDE (1972) failed to find evidence of amyloidosis after reviewing 33 cases of renal vein thrombosis. In all the present cases the renal vein was open. This differential diagnosis has to be considered with a nephrotic syndrome, however, and if it is difficult to demonstrate the renal vein from the arterial side, phlebography should be performed, eventually enhanced by the introduction of epinephrine into the renal artery (OLIN & REUTER 1965). The angiographic findings in renal amyloidosis may from the differential diagnostic point of view resemble those in chronic glomerulonephritis in which non-filling of the interlobular arteries and an indistinct

corticomedullary junction are fairly common (EKELUND et coll 1972) In glomerulonephritis, however the more proximal intrarenal arteries are usually only slightly involved The differential diagnosis against chronic pyelonephritis may be impossible in the end stage with contracted kidneys A clinical history of a chronic condition such as osteomyelitis or polyarthritis should however keep the diagnosis of renal amyloidosis well to the fore

SUMMARY

The angiographic findings in 6 patients with histologically verified renal amyloidosis both primary and secondary are presented All the patients had abnormal angiograms but renal vein thrombosis was not encountered

ZUSAMMENFASSUNG

Die angiographischen Befunde bei 6 Patienten mit histologisch nachgewiesener renaler Amyloidose *sowohl primärer als auch sekundärer werden beschrieben Alle diese Patienten* hatten pathologische Angiogramme jedoch wurden keine Nierenvenenthrombosen gefunden

RÉSUMÉ

Présentation des signes angiographiques constatés chez 6 malades atteints d amyloïdose rénale vérifiée histologiquement primaire et secondaire Tous ces malades avaient des angiographies anormales mais on n a pas trouvé de thrombose des veines rénales

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THREE DIMENSIONAL SELECTIVE ANGIOGRAPHY IN THE DIAGNOSIS OF RENAL MASSES

V. HEGEDÜS

The aim of the present communication is to evaluate the advantage of three dimensional selective angiography of the kidney in the diagnosis of renal masses. This method has been used earlier for estimation of the in vivo volume of the kidney and its cortical volume and for the demonstration of the arterial anatomy of the kidney (HEGEDÜS 1972, HEGEDÜS & FAARUP 1972, HEGEDÜS & RASMUSSEN 1972).

The material consists of proven cases of kidney cysts and tumours examined at the Department of Diagnostic Radiology, Lund, between 1970 and 1972 (38 patients) and at the Department of Diagnostic Radiology, Strong Memorial Hospital between 1972 and 1973 (23 patients). In 61 patients 63 kidneys with mass lesions were examined. The cases represent 37 kidneys with solitary or multiple cysts and 26 kidneys with tumours, in one of the latter both tumour and cyst being present. The 36 male and 25 female patients were between 38 and 77 years of age and in fairly equal distribution.

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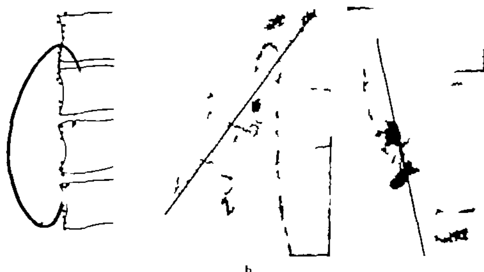


Fig 1 The ventral distal open angle (V—D angle)) The angle is formed by the intersection of the long axis of the kidney and a line drawn from the anterior edge of the vertebrae immediately adjacent to the upper and lower poles of the kidney I normal material this angle ranges between 0 degrees and 4 degrees The majority of normal kidneys have V—D angle between 6 degrees and 1 degrees (Hegedus 1972) b) Tumour in right kidney involving the dorsal lower portion V—D angle 35 degrees) Tumour in right kidney involving dorsal part upper portion of kidney V—D angle inverse 22 degrees

Method In all cases aortography preceded the examination The three dimensional elective angiography according to previous publications (Hegedus 197?) was performed as follows

Through a thin walled catheter 8 to 14 ml of contrast medium was injected with the aid of an injector The speed of injection was 10 ml per second A serial angiography was first made in the anterior posterior projection followed by a series in the true lateral position of the kidney for demonstration of the ventral and dorsal surfaces This position was obtained as follows The patient was placed on the ipsilateral side With the aid of fluoroscopy during the injection of approximately 5 ml of medium into the renal artery slight rotation dorsally gave a true lateral position for that kidney The films obtained in both projections should include the early arterial arteriolocapillary nephrographic and venous phases

Evaluation of the films included in the lateral projection also measurement of the ventral-distal open angle (V—D angle) between the sagittal axis of the kidney and that of the body (Fig 1)

The diagnoses were confirmed in the cyst material by puncture aspiration and histologic examination of the fluid In addition the cysts were filled with

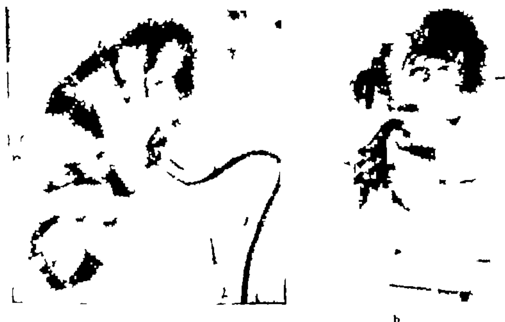


Fig 2 Female aged 68 admitted for flank pain on right side) A p projection no changes
b) Lateral projection cyst 5 5 cm in diameter t entral middle portion f the kidney

contrast medium and radiologically examined All patients in the tumour group were op rated upon and the diagnoses confirmed by pathology Autopsy was per formed in two cases

Results

The V—D angle measurements presented great variations as compared with the normal angles In 38 cases (60 per cent) depending on the site of the mass lesion severe distortion of this angle was registered, the extremes being 42 degrees and inverse 24 degrees (Fig 1) Of the remaining 25 cases (40 per cent) where the V—D angle was within normal limits 17 kidneys had cysts and 8 tumours

In 37 cases (23 cysts and 14 tumours) the three-dimensional angiography re sulted in exact localization of the lesion in relation to the adjacent tissues In the remaining 26 cases (14 cysts and 12 tumours) the method used resulted in even greater diagnostic advantages as follows

Cysts In 8 cases the cyst was nly demonstrated in the lateral projection (Figs 2 3 4) and in 2 cases this projection revealed additional cysts In 3 cases only



Fig 3 Female aged 56 Incidental finding of left renal mass at urography for hypertension a) A p projection no mass lesion recognizable b) Lateral projection cyst adjacent to middle dorsal portion of the kidney

the combination of the two projections allowed for clear differentiation between cyst and tumour (beak effect only in the lateral view) In one case the three dimensional method revealed severe distortion and compression of the perirenal structures (Fig 5)

Tumours The selection of the surgical approach (flank or transperitoneal incision) was dependent on the three dimensional information in 9 cases In 6 case avascular mass lesions in the retrorenal space i e the presence of lymph node metastases were inferred (Figs 6 7) In 3 cases no mass lesions in the retrorenal space were demonstrated and on operation there was no evidence of metastases in regional lymph nodes In 4 cases involvement of other organs (peritoneum colon diaphragm pericardium ribs) was suggested and confirmed at surgery (Figs 7 8) In one case (Fig 9) the vascular anatomy of the tumour in a solitary kidney was precisely described thus allowing enucleation of the tumour

Four representative cases from the tumour material may be presented

Case 1 Female aged 62 admitted with chief complaint of episodes of gnawing pain in the right abdomen and flank *Urography* A large rounded mass in the lower pole of the

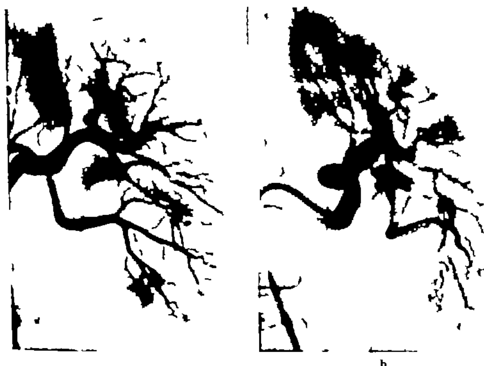


Fig 4 Female aged 68 Incidental finding of left renal mass t urography for hypertension) A p project on no abnormal ty b) Lateral projection cyst in lower dorsal portion of the kidney \—D angle slightly increased to 26 degrees

right kidney ith no evidenc f obstruction to draining structures *Angiography* (Fig 6) A round poorly ascularized tumour at the lower dorsal portion f th kidney Severe dist tion and anterior displacement of the kidney and renal ein indicated extensive tumour growth in the retrorenal space *Operatio* Transperitoneal pproach Right radical ephrec tomy Additional mass underneath th ena ca at the level f the renal pedicle and en larged lymph nodes cranial of the origin f the renal artery *Path l gy* Adenocarcinoma ith extensive necrosis ein involvement and metastases in the regional lymph nodes Un remarkable postoperativ course Radiation therapy

Case 2 Male aged 69 admitted with hist ry of cough fever and weight loss Chest film revealed multiple metastases in both lungs *Urography* A mass in the right kidney *A gio gr phy* (Fig 7) A richly ascularized round ell-demarcated tumour in the right kidney ith anterior extension and possibl peritoneal involvement The displacement of the renal ein and axis of the kidney indicated retrorenal involvement *Operatio* Transperitoneal pproach Right nephrectomy Tumour inv l ement of the peritoneum and the serosa f th colon Enlarged regional lymph nodes *Pathol gy* Moderately differentiated renal cell ca cinoma Tumour growth in h regional l mph nodes Involvement f the serosa of th ascending colon Unremarkabl po toperat ourse Radiation therapy



Fig 5 Female aged 47 dmitted for right flank pain and palpable abdominal mass a) A P projection ascula mass rth 18 cm maximal diameter distorting and displacing right kidney bx midline Obstructed renal ein outlined by contrast medium b) Lateral projection large cyst arising from entral surface of kidney With the patient in thi position the renal ein paten although obstructed and the nferior ena cava (rrow) is demonstrated kidne dis pla ed between ena ca nd spine

Case 3 Mal aged 66 admitted with history of weight loss fatigue and palpabl left abdominal mass Blood chemistry revealed severe nemia and mild icterus *Urogr phy* A large mass invol ing the lower portion f the left kidney *Angiogr phy* (Fig 8) A large infiltrat ing tumour involving the lower portion of the left kidney and the ntero and retrorenal spa es Shunting between the renal and nferior mesenteri ves els and direct tumour growth into ribs 11 and 12 *Operatio* En bloc nephrectomy splenectomy segmental colectomy and pancreas esection Death 4 weeks after the operation with perforated gastri ulcer Klebsiella septicemia and sever cardiac failur *Pathol gy and aut psy* I filtrating anaplastic sarcoma or lymphoma involving the kidney dorsal abdominal wall tail f th pancreas spleen peritoneum and descending olon

Case 4 Female aged 63 admitted with sole complaint of hematuria Four years before this admittance right nephrectomy for carcinoma Multiple subsequent negative metastatic survey On admission microscopic hematuria only abnormal finding *U ography* Distortion of the calyces in the middle portion of the solitary left kidney *Metastat c survey* Negativ *A giography* (Fig 9) No recurrence at th site of the previous operation Small round tumour in th mid dorsal portion of th left kidney mainl supplied by one branch of the

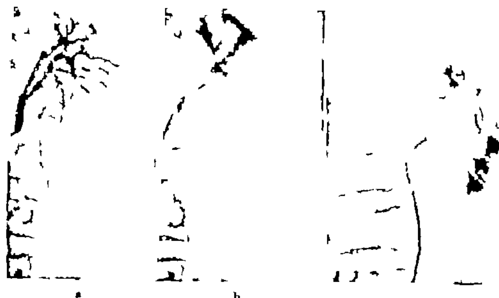


b

Fig 6 Case 1 Right kidney) A p projection large cyst like ma di tally in the severel distorted kidney b) Lateral projection the main lesion ari es from dorsal middle portion of kidney and di places its lo er pole cranad The lesion ha thick ascular wall tov ards the kidney (rrow) and is supplied dorsally by few abnormal rteries I addition the entire kidney is displaced entrad Artery from tumou directed into the retrorenal space) La eral projection enous phase displa eins draining the tumour and sever entral dislocation of the main renal ein (rro)

b

Fig Case 2 Right kidney \ p p jection large tumour mediall lower port on b) Lateral projection tumour protr des ards peritoneum De pite this \ —D ngle is 30 degrees Furthermore the upper tta hed to the tumour resulting entral disloca tion ho indicatn of mass I ret l space Ventral displacement of main renal ein (arrow) suggests enlargemen of l l y h nodes



F g 8 Case 3 Enlargement of left kidney A p projection in arterial ( ) and enous (b) phases large diffusely growing tumour with enous return through inferior mesenteri eins indicating tumou inf ltration of descending colon) Lateral projection extensiv growth in retrorenal space with filtration f the two lower ribs

mai renal artery Separate venous drainage from th tumour N abnormalities suggesting infiltration of other parts f th kidney or extrarenal tissues *Operatio* Easy identification and clan ping of the supplying and draining essels followed by injection f methylene bl e into the arterial branch supplying th tumour Enucleation f th demarcated tumour with small margins in normal kidney tissue Lymph node biopsies *Pathology* Moderately dif ferentiated renal cell carcinoma surrounded by compressed f brotic renal tissue No ev dence f lymph node metastases *P stoperati c urse* Mild transient uremia (serum crea t nin ma 3 0 mg %) for 2 weeks Urinary fistula t the skin closed spontaneously fter 4 weeks After further 4 weeks f ll time work in her earlier occupation

Discussion

Angiography of the kidney is now routine in the investigation of renal masses In spite of the nonspecificity of abnormal vascularity of malignant neoplasms (VIAMONTE et coll 1973) pharmacologic interventions may enhance the ac curacy of the procedure (ABRAMS 1964 CARO et coll 1969 EKELUND et coll 1972)

Further improvement in diagnostic accuracy has been achieved by needle aspiration of avascular renal lesions (LINDBLOM 1946 THORNBURY 1972) False negative cyst punctures i e failing to detect occult tumour in the cyst wall are



Fig 9 Case 4 Solitary left kidney) A p projection small [illegible] middle portion of kidney Early filling of small vein draining [illegible] [illegible] shunting in the tumour (arrow) b) Tumour located [illegible] [illegible] kidney [illegible] tion of the central and lower portions It is obvious that the lesion is mainly [illegible] first primary branch of the renal artery which has extrarenal origin Three [illegible] graphy was essential for planning enucleation of the tumour with maintenance [illegible] ing amount of parenchyma

fortunately very uncommon but a few cases have been published ([illegible] 1961 BARTLEY & HELANDER 1962 BRANNAN et coll 1962 [illegible] WATSON et coll 1968) The three dimensional localization may yet further enhance the accuracy of needle placement with less damage to normal surrounding tissues In the cases presented here all cyst punctures were successfully performed without late complications or discomfort for the patient Most important however is the fact that in 8 out of 37 investigations cysts were detected only in the lateral projection (Figs 2 3 4) The largest cyst unrevealed in the a p view had a diameter of 6 cm In one case two cysts clearly demonstrated in the lateral projection failed to be demonstrated in the a p view

The lateral projection was instrumental in the detection of extension of tumour into the surrounding tissues and regional lymph nodes In many cases tumour extension towards the anteriorly lying intraperitoneal structures (Fig 7) or intrathoracic direct infiltrative growth were detected or infiltration of the retrorenal space (Figs 6 7 8) suggested In some cases (Figs 6 7) displacement of the renal vein indicating growth of tumour in the area of the regional lymph nodes, was noted To our knowledge no similar findings have been published In the entire series false positive lymph node metastases were reported in two cases, while in three cases evident lymph node metastases at operation were not demonstrated Case 4 is particularly interesting The patient had already years before lost the contralateral kidney and the tumour occurred in the solitary kidney The three dimensional angiography was necessary to define the exact site of the tumour its arterial supply and venous drainage Thus it was made clear before exploration that resection of the lesion was possible with maintenance of a sufficient amount of kidney parenchyma (Fig 9)

Measurement of the V—D angle in the cyst material provided additional information about the possible displacements of the kidney caused by the adjacent space occupying lesion However in the tumour material the displacement of the kidney and distortion of its axes were of essential diagnostic importance In one of our cases, in addition to the increased V—D angle, the entire kidney was displaced ventrad, indicating besides the tumour an avascular mass lesion in the retrorenal space In case 2 despite the anterior site of the tumour the V—D angl was increased which indicated that the displacement due to the tumour was more than compensated for by an even larger mass in the retrorenal space In another case the entire kidney was displaced ventrad without distortion of the V—D angle indicating extensive tumour growth in the retrorenal space

It seems that the appreciation of an abnormal V—D angle has the most important diagnostic significance when unexpected as it would indicate an additional avascular mass lesion prohibiting a logical displacement of the kidney

Although renal masses are successfully examined by nephrotomography (EVANS et coll 1955) ultrasound (GOLDBERG et coll 1968) isotope scanning (ROSENTHALL 1966) angiography (FOLIN 1967) and pharmacoangiography (ABRAMS 1964 EKELUND et coll 1972) three dimensional angiography gives additional information not derivable from the other techniques The ventral and dorsal surfaces of the kidney are demonstrated the vessel distortions and displacements recognizable only in the third dimension, the antero- and retrorenal spaces and an abnormal position of the kidney can be truly defined only by three dimensional angiography but usually no increased information about the vascularity of the lesion is obtained However the information may approach a qualitative level, which may be decisive when selecting the prop r therapy

SUMMARY

Three dimensional ngiographs of the kidney may enhance inform tion derived from con entional tw dimensional angiography The ascular topogr phy of renal mass lesions is better defined the distortion f the position of th kidney is determined nd the antero and retrorenal spaces may be investigated

ZUSAMMENFASSUNG

Di dreidimensionale Angiographie der N ere kann die on einer herkommli h zweidimen ionalen Angiographie erhaltene Information erhohen Die vaskular Topogr phi expan siver Nierenprozessen ist bes er definierbar die Distorsion der Lage der N ere besser be timmbar und die anterioren und retrorenalen Abschnitte las en sich untersuchen

RESUMÉ

L angiographie tridimensionnelle d rein peut completer les informations obtenues par l an iographie bidimensionnell ordinaire La topographie asculaire des lesions tumorales renales est mieux definie les modifications de la position du rein sont precisees et on peut examiner les espaces pre et retrorenaux

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ANGIOGRAPHY IN COLLAGENOUS DISEASE OF THE KIDNEY

L. EKELUND and T. LINDHOLM

Reports on the angiographic findings in collagenous disease of the kidney are sparse most of them dealing with polyarteritis nodosa (BRON et coll 1965 FLEMING & STERN 1965 CHUDACEK 1966 1967 EFSEN & LORENZEN 1968 MC CLURE & WESTCOTT 1969 ROBINS & BOOKSTEIN 1972) Vascular abnormalities of the kidney in two cases of scleroderma with renal failure were published by LESTER & KOEHLER (1971) No reports on angiography in systemic lupus erythematodes can be traced As abnormalities may be marked it seemed worth while to analyze the angiographic findings in a series of patients with collagenous disease of the kidney and also to try to relate these to the clinical signs and stage of the disease

Material and Methods Th material consisted of 6 patients with systemic lupus erythematodes (S L E 2 with polyarteritis nodosa, 1 with progressive systemic sclerosis (scleroderma and 1 patient with Wegener s disease The age sex and clinical diagnoses are given in Table 1 all the patients with S L E were women The patients were examined by transfemoral bilateral elective angiography of the kidneys in ne in tan es preceded by abdominal aortography

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Table 1

Age, sex, diagnoses and clinical findings in the present material

Case	Age	Sex	Diagnosis	Serum creatinine mg % (at time of angiography)	Blood pressure mm Hg	Antihypertensive therapy
1	50	F	S.L.E.	0.8	1[illegible]/90	No
	37	F	S.L.E.	0.8	130/90	No
3	3[illegible]	F	S.L.E.	0.65	130/95	N[illegible]
4	[illegible]1	F	S.L.E.	2.6	140/80	N[illegible]
	[illegible]1	F	S.L.E.	1.7	140/90	N[illegible]
6	[illegible]0	F	S.L.E.	1.9	140/90	Yes
	56	M	Polyart. nodosa	5.1	140/[illegible]5	No
8	[illegible]	M	Polyart. nodosa	0.85	165/110	No
9	[illegible]4	F	Scleroderma	18.0	160/100	Yes
10	[illegible]2	M	Wegener disease	1.2	110/75	N[illegible]

The angiograms were evaluated according to the following criteria: Kidney size, calibre of main renal artery, appearance and filling of intrarenal arteries and cortical width and definition of the boundary between the cortex and medulla as well as the renal circulation time and demonstration of the renal vein.

The renal function was reduced in 2 patients with S.L.E. One of these (Case 6) was admitted to the clinic for the first time in 1965 with oliguria. She was treated with haemodialysis four times before diuresis was obtained by corticosteroids. Angiography of the kidneys was performed in 1968. Cases 7 and 9 were admitted because of oliguria. Case 7, the man with polyarteritis nodosa, improved during immunosuppressive therapy but the woman (Case 9) with scleroderma died some weeks after the angiography.

Elevated blood pressure (160/100 or more) was recorded in 2 patients, one of whom was under antihypertensive therapy; the blood pressure in a further patient on antihypertensive drugs was normal (Table 1).

The clinical diagnoses were confirmed by renal biopsy in 7 patients. Three patients (Cases 5, 7, 9) died.

Case reports

Case 4. Woman, aged 51, who for two years had had three episodes of fatigue, subfebrility and muscle and joint pains. A serum creatinine concentration of 4.0 mg per cent led to her admission. She had proteinuria of the glomerular type and the urinary sediment in each visual field contained more than 20 red blood cells and occasional granular casts



Fig 1 Case 4 Systemic lupus erythematodes Selective angiography of the right kidney I terlobar arteries narrowed towards the periphery Non filling of interlobular arteries and indistinct boundary between cortex and medulla) Arterial b) nephrographic phase

Urography was normal Fibrin degradation products were present in th serum but not in the urine Renal biopsy revealed dvanced glomerular changes the arteriolar walls were hyalinized and fibrinoid necrosis was also evident The ppearances were considered consistent with chronic glomerulonephritis possibly on the basis of collagenosis

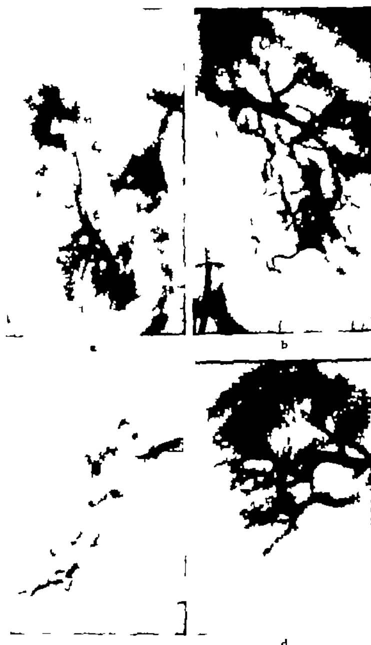
Angiography Kidney of normal size the cortical arteries were not filled and the boundary between the cortex and medulla was indistinct (F g 1)

The findings of products of fibrin degradation in the serum suggested intra enous heparin treatment this was given for 8 day ithout any obvious effect Treatment with corticost roids was instituted week later The gen ral condition of the patient then rapidly im proved although renal function was st ll educed with the serum creatinine alu t 2 mg per cent

Earlier muscl biopsy had revealed normal conditions but biopsy six months later of a superficial ulcer f the tip of the right ear disclosed intradermal asculitis compatibl with collagenosis The treatment with the steroids failed to alter the degree f proteinuria The blood pressure as well as the ocular fundi were normal throughout

Case 7 Ma ged 56 with bronchial asthma from youth had seven months previously noticed that his legs ere swollen The haemoglobin was 8 8 g per cent the ESR 148 mm per/h and the proteinuria 0 3 per cent Anti treptolysin titre and antinu lear factors er positi During the first month f observ tion th serum creatinine concentration rose from 2 mg to 10 mg per cent The blood pressur as normal Renal biopsy revealed dvanced necrotizing diffuse glomerulonephritis and asculitis of the fibrinoid type th latter was also evident in the ssels from muscle biopsy

Angiography Enlarged right kidney normal size of left kidney Narrowing of interlobar arteries and nonfilling of interlobular arteries Indistinct boundary between the cortex and medulla No infarction and no arterial aneurysms



F g 2 Case 8 Polvarter tis nod a) Left kidney Selectn angiography Insufficient filling of entral rtery Dorsal rtery ppears normal l) Left kidney 12 month later Widespread tenoses ha dev loped in entral as w ll as dorsal rt ry Collateral irculation ia lower capsular rtery) Right kidne Stenoses dorsal artery most marked in proximal part I farction laterally in lower pole d) Right kidney 24 months h er Dorsal rtery almost ccluded 1 cm from ori,



Fig 3 Case 8 Superior mesenteric angiograph Stenosis of coeliac artery with collateral circulation in pancreatic arcades Irregular stenoses in main stem of superior mesenteric artery distal to ileocolic artery (→) 5 cm long occlusion of one ileal artery which fills via collaterals (⟶)

The patient was given prednisolone initially 75 mg per day and azathioprine 150 mg per day the renal function improved and the serum creatinine decreased t 1 6 mg per cent One year later th renal function was essentially unchanged but later on it deteriorated again and the patient died in spite of the immunosuppressiv treatment

Case 8 Man aged 27 who had had intermittent attacks f fever and joint pains for fiv years was admitted with anaemia an ESR f 60 mm/h and considerabl loss f weight An extensiv examination including angiography performed about four months previously had produced no definit diagnosis (Fig 2) about this time arterial hypertension developed and as this was drug resistant a further examination was carried out

The ocular fundi had hypertensiv changes grade III Keith Wagener and antinuclear factors were now revealed with the fluorescenc techniqu Further angiography f the kidney disclosed multipl arterial stenoses (Fig 2 b) Renal biopsy indicated that some glomeruli were almost hyalinized an increased number of cells and thickened basal membrane were evident in others The micro copy ppearances were consistent with subacut glomerulonephritis but considering the other clinical findings the patient was labelled as having arteritis

Further angiography after another tw year demonstrated progression f the arterial changes in the right kidney but no changes on the left side (Fig 2 d) Superior mesenteric angiography was also performed at this time and demonstrated marked vascular changes (Fig 3)

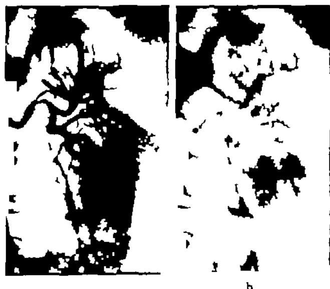


Fig 4 Case 9 Scleroderma Selective angiography f left main renal artery (The kidney is also supplied by lower polar artery) Stenosis of main stem (confirmed at previous ortography) Multiple irregular arterial stenoses and prolonged circulation time I regula kidney surface) Early b) late phase

Immunosuppressive treatment was started w th azathioprine 150 mg and prednisolone 15 mg daily in ddition to antihypertensiv therapy The clinical cond tion of the patient improved remarkably The steroid therapy was withdrawn but azathioprine is still being given (July 1973) The blood pressure is also under control t the moment with a β blocking gent (I deral 280 mg daily) betanidine (Esbatal 40 mg daily) and hydrochlorthiazide (Esidrex 25 mg daily) The eyeground changes ha e regressed and are now grad I Keith Wagener The renal function measured as endogenous creatinine clearance has always been normal in spite of the changes evident at angiography as well as at biopsy The general ondition f th patient is excellent and h is working full time

C 9 Woman aged 45 with tenosynovitis in both wrists for 9 months and hyperpig mentation with the leg and th forearm similarly ffected for 3 months biopsy of the skin disclosed corium abnormalities indicating scleroderma Treatment with steroids was in stituted A few weeks later sh was admitted after a grand mal convulsion The blood pressur previously normal was 210/130 mm Hg The fundi had hypertensive changes grad IV Keith Wagener

Angiography Stenosis f both main renal arteries Multiple irregula intrarenal artery stenoses and prolonged circulation time Irregular kidney surface (Fig 4)

The blood pressure was brought down t almost normal with dihydralazine (Nepresol) and bet nidine (Esbatal) but despit this the patient had signs of cardiac failure with incipient pulmonary oedema The amount of urine excreted gradually decreased uremia supervened nd peritoneal dialysis was inaugurated Th general condition of the patient deteriorated however and she died three weeks fter admission

Autopsy revealed collagenous disease of the type progressive systemic sclerosis M ltiple small cortical farctions were present in the kidney The intima f the small and middl sized arteries was hyperplastic and thickened as occurs in malignant nephrosclerosis

Table 2

Angiographic findings in 10 cases of collagenous disease of the kidney

Case	Diagnosis	Kidney size	Renal artery			Cortical width	Boundary between cortex and medulla
			Main stem	Interlobar arteries	Interlobular arteries		
1	SLE	Normal	Normal	Normal	Normal	Normal	Distinct
2	SLE	Normal	Normal	Nontapering	Normal	Normal	Distinct
3	SLE	Left slightly reduced	Normal	Normal	Nonfilling	Localized reduction	Indistinct
4	SLE	Normal	Normal	Normal	Nonfilling	Slightly reduced	Indistinct
5	SLE	Increased	Normal	Slightly widened	Nonfilling	Normal	Indistinct
6	SLE	Decreased	Normal	Narrowed	Nonfilling	Reduced	Indistinct
7	Polyart nodosa	Normal left Increased right	Normal	Narrowed	Nonfilling	Reduced	Indistinct
8	Polyart nodosa	Normal (infarct)	Normal	Stenoses and occlusions	Reduced filling	Infarctions	Indistinct
9	Sclero-derma	Normal	Stenoses	Tortuous and irregular	Nonfilling	Reduced	Indistinct
10	Wegener disease	Normal	Normal	Normal	Normal	Normal	Normal

The angiographic findings in the 10 patients with collagenosis appear in Table 2. The angiography was normal in one of the 6 patients with systemic lupus erythematodes—all women—and one patient had only minor pathologic changes in the form of somewhat widened interlobar arteries that were non-tapering. The remaining 4 patients had one characteristic in common: nonfilling of interlobular arteries and an indistinct boundary between the cortex and medulla. Two of these patients had kidneys of normal size. In one 21-year-old woman with acute exacerbation of the disease, the kidneys were swollen and the intrarenal arteries widened and stretched, while in another case of longstanding disease the kidneys were shrunken. The renal vein was always patent.

Both patients with polyarteritis nodosa had vascular abnormalities ranging from narrowing and irregularity of peripheral interlobar arteries and nonfilling of arcuate and interlobular arteries to marked irregularities and even occlusions of more proximal arteries with ensuing infarctions of the kidneys. Arterial aneurysms were not encountered.

The most advanced vascular abnormalities occurred in an uremic patient with progressive systemic sclerosis. Finally, in the 52-year-old man with Wegener's



Fig 5 Angiograph of the left kidney in ea old man with reduced renal function Stenoses and aneurysmatic widening of intrarenal arteries suggesting collagenous disease Autopsy revealed only bilateral arteriolosclerosis (The patient died from prostatic carcinoma)

disease and pulmonary involvement but with normal renal function angiography was normal Renal biopsy demonstrated marked glomerular changes but only suggested the presence of vasculitis

Discussion

Connective tissue alterations are characteristic features in collagenous disease (KLEMPERER 1950) This includes S L E polyarteritis nodosa, scleroderma Wegener s disease and rheumatoid arthritis

The degenerative changes in S L E occur in the glomeruli thus resembling glomerulonephritis The angiographic findings were therefore of the same type as described in glomerulonephritis where impaired filling of interlobular arteries and an indistinct boundary between the cortex and medulla are fairly common (EKELUND et coll 1973) Similar changes may also occur in renal amyloidosis, although in the latter interlobar arteries are usually also involved (EKELUND & LINDHOLM 1974)

Polyarteritis nodosa is a systemic disease characterized by fibrinoid necrosis of the vessel walls Renal involvement is reported in about 80 per cent of the cases (DAVSON et coll 1948 ROSE 1957) These vascular lesions may lead to arterial occlusions and subsequent infarctions of the kidneys The findings at nephro-

angiography have been described CHUDACEK (1966) and FYBEN & LORENZEN (1968) reported one case each with rarefaction of peripheral arteries and heterogenous nephrography Multiple aneurysms of intrarenal arteries have been described by FLEMING & STERN (1965) BRON et coll (1965) CHUDACEK (1967) MCCLURE & WESTCOTT (1969) and ROBINS & BOOKSTEIN (1972) These aneurysms may be transitory in nature and regress as described in the two last mentioned reports In neither of the present 2 cases were aneurysms demonstrated In one case, however marked vascular changes with arterial irregularities and occlusions with ensuing infarctions of the kidneys occurred progression could be demonstrated at repeat angiographies Superior mesenteric angiography in this case also demonstrated stenoses and occlusions of intestinal arteries Vascular changes in the mesentery in polyarteritis nodosa have previously been reported by RABINOVITCH & RABINOVITCH (1954) POOH & STRINGER (1956) and CHUDACEK (1967)

Arterial changes in the extremities in scleroderma have been described by VOOLER & GOLLMANN (1953) and by SCHOBER & KLUKEN (1966) Renal vascular changes demonstrated at angiography it would appear have been described only in 3 cases so far 2 by LESTER & KOEHLER (1971) and 1 by GROLLMAN et coll (1970) The findings of LESTER & KOEHLER i e irregular arterial narrowing tortuosity of intrarenal arteries prolonged circulation time and poor nephrographic effect were the same as in the present case which also had stenoses of both main renal arteries The statement of these authors that the development of renal signs in patients with scleroderma is quickly followed by death would seem true even in the present instance

It is thus evident that with some progression of the renal disease in collagenosis marked vascular changes may be an important feature From the differential diagnostic point of view similar changes may occur in arteriolosclerosis of the kidney (Fig 5) but are usually less prominent

SUMMARY

The angiographic findings in 10 patients with collagenous disease of the kidney are presented in systemic lupus erythematodes they were of the same type as may occur in glomerulonephritis The most advanced vascular changes were evident in one case of polyarteritis nodosa and in one of scleroderma

ZUSAMMENFASSUNG

Die angiographischen Befunde bei 10 Patienten mit einer Kollagenose der Nieren werden beschrieben diese waren bei dem generellen Lupus erythematodes om gleichen Typus wie sie bei der Glomerulonephritis auftreten konnen Die am starksten fortgeschrittenen vaskulären Veranderungen lagen in einem Fall von Polyarteritis nodosa und in einem von Sclerodermia vor

RÉSUMÉ

Present tion des r sultats angiographiques chez 10 patients atteints de malad e du col l gène à localisation rénale dans de l pus rythémateux systémique ces signes étaient du nem type que eux qui peuvent exister dans la glomérulonéphrite Les mod f cations sc laires les plus avancees ont ete trouvees dans un cas de polyartérit noueuse et dans n s de sclerodermie

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LUNG AERATION IN THE FULLTERM NEWBORN RABBIT

Roentgenologic and histologic investigations

GERTIE GROSSMANN B LAMKE and B ROBERTSON

The adaptation of the fetal mammalian lung to extra uterine life involves a series of events which must be smoothly coordinated to ensure the survival of the newborn Vigorous respiratory movements are required in the initial phase of lung aeration to overcome the surface forces in the peripheral airspaces particularly in individuals with inadequate amounts of surfactant phospholipids in the pulmonary fluid Furthermore the pulmonary vascular resistance must decrease to enhance the pulmonary blood flow and the lymphatics of the lungs must begin to remove interstitial pulmonary fluid Under normal circumstances a favourable ventilation perfusion relationship is quickly established but in case of pulmonary prematurity the aeration and perfusion of the lungs are frequently hampered leading to a condition known clinically as the idiopathic respiratory distress syndrome

The purpose of the present investigation was to analyse the neonatal adaptation of the fullterm rabbit lung with roentgenologic and histologic techniques with particular reference to the aeration of the parenchyma in relation to the

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resorption of fetal pulmonary fluid The results will serve as a basis for similar investigations on premature fetuses, in which tracheal deposition of surfactant phospholipids has been used as a prophylactic measure against neonatal respiratory distress (cf ENHORNING & ROBERTSON 1972 ENHORNING et coll 1973)

Material and Methods The experiments were carried out on 44 nearly full term rabbit fetuses 24 for roentgenologic and histologic evaluation of lung aeration and 20 for determination of the wet weight of the lungs

Pregnant female rabbits, whose time of mating was known within a range of two hours, were killed by intravenous injection of 5 ml 2M KCl after gestation 30 days less 2 to 6 hours (fullterm = 31 ± 1 days mean ± SD) The abdomen was opened and the upper part of the vagina clamped with a large hemostat The fetuses were then delivered through random uterine incisions

Four animals from each litter were used for roentgenologic examination The respiratory movements were first prevented by the application of a rubber stall covering the mouth and the nose The animals were then loosely affixed to a sheet of cardboard, by means of strips of gauze, and a first exposure made (a p projection only) within an average of 5 min (range 3 5 to 9 min) after the beginning of the surgical procedure The rubber stalls were then removed simultaneously and a second analogous exposure was made 5 to 6 seconds after the first one Further exposures were made at the following intervals 10 20 30 s 1 2 3 4 5 10 15 30 45 60 90 and 120 min after the removal of the rubber stalls

Regular respiratory movements were observed in all fetuses within a few seconds after removal of the rubber stall and they all continued to breathe without apparent discomfort throughout the experiment The fetuses were killed with intraperitoneal Nembutal 15 30 60 or 120 min after removal of the rubber stalls and the unopened thorax was fixed with formalin 10 % for a week then sliced transversally at the level of the cardiac ventricles and embedded in paraffin From these blocks 10 μ thick microtome sections were cut and stained with hematoxylin and eosin

In addition to routine microscopy lung volume proportions were analysed morphometrically with an integrating eye piece of point-counting type (CHALKLEY 1943) The relative volume (V) of the following two compartments was determined

Alveolar lumen alveolar and alveolar duct spaces i e all airspaces distal to the terminal bronchioles

Parenchyma alveolar walls, pulmonary blood vessels and lymphatics, peribronchial and septal tissue and any other component of the lung which cannot be referred to as airspace lumen

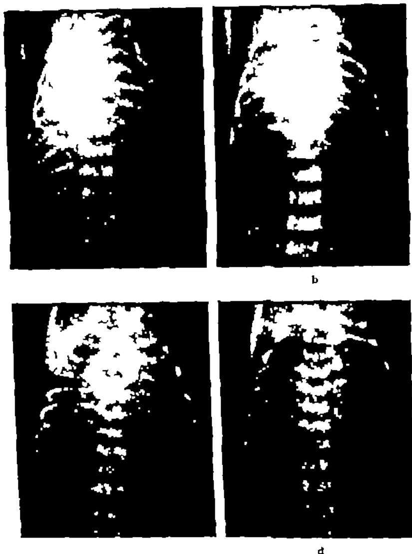


Fig 1 Lung films from nearly fullterm rabbit fetuses before and after the first breath ×2.5) Before onset of breathing No r belo the trachea the ribs are directed caudally b) Six seconds after the removal of the rubber stall The lungs seem to be completely aerated) Two min after the removal of the rubber stall The upper ribs ha assumed transverse position d) Two hours after the onset of breathing The ribs hav assumed an intermediate position constant feature throughout the series No further aeration of th lungs as compared with (b)

The entire transverse section of the lung was screened in each case and the degree of alveolar expansion was calculated as follows

$$\text{Alveolar expansion index} = \frac{V_{\text{alveolar lumen}}}{V_{\text{parenchyma}}}$$

Six additional fetuses were killed in utero and their lungs were analysed histologically using the morphometric method described above

In a separate series, 20 fetuses were killed with intraperitoneal Nembutal at the intervals 0 15 30 60 and 120 min after delivery The thoracic cages were opened and the main bronchi were cut close to the lung parenchyma After removal of the heart, the esophagus and the mediastinal tissue the lungs were weighed together and the ratio between the wet weight of the lungs and the body weight was calculated

Results

No air was found in the lungs on films obtained before the first breath (Fig 1 a) After the onset of breathing usually within 10 s after the removal of the rubber stalls a radiographically complete aeration of both lungs appeared The fetal position of the ribs (cf Fig 1 a) did not change during this initial phase of aeration (Fig 1 b) During the following two minutes the thoracic volume seemed to increase gradually as estimated from the elevation of the upper ribs to transversal position (Fig 1 c) Later the ribs consistently assumed an intermediate position i e they were more elevated than before onset of breathing but deflected in comparison with the aforegoing transversal position (Fig 1 d)

In one animal no air could be observed in the parenchyma of the lungs until 30 seconds after removal of the rubber stall only the bronchi were air filled during the whole experiment (15 min) Another fetus, after 15 min of normal breathing had a transient period without aeration of the lungs lasting 15 min On the subsequent films (45 min 1 h) there was a gradual transition to a normal appearance

In lung sections from animals that had been killed before the onset of breathing the alveoli had the shape characteristic of the fluid filled state i e they were uniform in size and their walls were wrinkled (Fig 2 a)

In all animals killed after 15 min including the fetus with only the bronchi air filled there was a patchy air expansion of alveoli and alveolar ducts Small areas of air filled somewhat overdistended alveoli and alveolar ducts with a rounded shape alternated with more extensive areas where the fluid filled alveoli had retained their fetal appearance (Fig 2 b) In many conducting airways

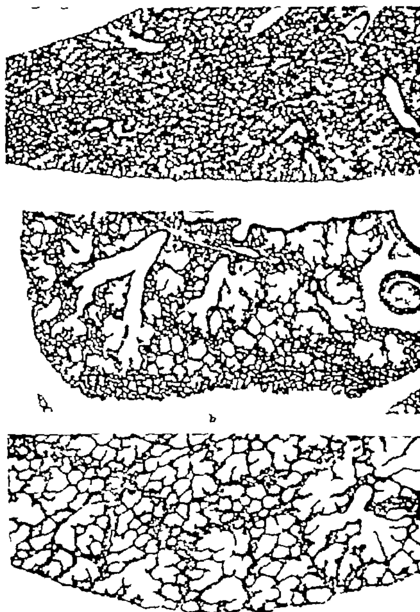


Fig 2 Microscopy of lungs of early fullterm rabbit fetuses (gestational age = 30 days) Hematoxylin and eosin ×33 a) Fetus killed in utero The alveoli are uniform in size and the walls are wrinkled representing the fluid filled state Alveolar expansion index = 0.5 b) Fetus killed 15 min after delivery Patchy air expansion with focal overdistension of alveoli and alveolar ducts alternating with unexpanded areas Alveolar expansion index = 1.07 c) Fetus killed 2 h after delivery The alveoli are more uniformly expanded with air although fluid filled areas still remain Alveolar expansion index = 1.04



Fig. 3. Air trapping in a bronchiole in rabbit fetus killed 15 min after delivery. An air bubble behind a pillar of unresorbed fetal pulmonary fluid. × 145.

air liquid interfaces were preserved as rounded menisci. In some areas there was also evidence of air trapping in preterminal airspaces peripheral to pillars of unresorbed fetal pulmonary fluid remaining in the bronchi (Fig. 3). At later intervals there was a gradual increase in the number of air filled alveoli but unexpanded areas still remained in animals killed 2 hours after delivery (Fig. 2 c).

The morphometric analysis of the lung sections corroborated the general impression, i.e. the initial aeration of alveoli was reflected by an increasing alveolar expansion index from an average of 0.46 before the onset of breathing to 0.70 at the age of 15 min ($p < 0.001$) (Table 1). At later intervals there was a considerable variation between the individual samples, but the mean values for the alveolar expansion index remained at approximately the same level as for 15 min after delivery.

The fetus in which the roentgenologic examination had revealed transient *non aeration of the lungs had a lower alveolar expansion index (0.40) than the* other animals killed at the same interval but did not otherwise deviate from the usual microscopic appearance.

The lung weight/body weight ratio was unaltered from 0 *to* 15 *min* after birth (Table 2). Thereafter the ratio gradually decreased throughout the period of observation. The difference between the groups 0 to 15 min on one hand and the groups 30 to 120 min *on the other is statistically significant* ($p < 0.001$).

Discussion

The results of the experiments can be condensed into three points, each of which has to be considered in relation to certain observations made by previous authors.

First, the aeration of the lungs of the fullterm newborn rabbit appears roentgenologically to be complete within a few seconds after the onset of

Table 1

Alveolar expansion index at various time intervals after delivery. The difference between animals killed in utero and those killed after 15 min is statistically highly significant ($p < 0.001$)

Postnatal age (min)	Alveolar expansion index		
	Range	Mean	SD
0	0 2 0 68	0 4[illegible]	0 1
1	0 41 – 1 09	0 [illegible]9	0 [illegible]4
30	0 39 0 77	0 57	0 1
60	0 40 – 1 01	0 60	0 14
1[illegible]0	0 31 – 1 04	0 60	0 [illegible]4

Table 2

Lung weight body weight ratio at various time intervals after delivery. The difference between the combined groups 0—15 min on one hand and the combined groups 30 — 1[illegible]0 min on the other is statistically highly significant ($p < 0.001$)

Postnatal age (min)	Lung weight/body weight (g/kg)		
	Range	Mean	SD
0	2[illegible] 29	2	3
15	21 32	[illegible]6	4
30	21 – 24	22	1
60	19 – [illegible]4	21	2
120	13 – 17	16	2

breathing This concept is in accordance with observations made by KARLBERG (1960) FAWCITT et coll (1960) and LIND et coll (1966) who examined the lungs of fullterm newborn infants immediately after delivery using serial films as well as cineradiography Their results suggested that the first breath of the infant leads to an overall aeration of the pulmonary parenchyma only a slight increase in the aeration of the lungs being noted during the subsequent first few hours of postnatal life These authors further reported that the neonatal aeration does not cause any significant change in the volume of the lungs to judge from the position of the ribs and the diaphragm before and after the first breath In the present experiments it was not possible to identify the position of the diaphragm before the first breath and the exposures were made in antero-

posterior projection only without regard to the respiratory phase of the fetus However since the fetal position of the ribs was unchanged in films obtained immediately after the onset of breathing we conclude that the first few breaths are mainly diaphragmatic The subsequent elevation of the ribs to transversal position further suggests that there is in the newborn rabbit a transient phase of hyperexpansion of the lungs occurring within the first few minutes after birth

Second the distribution of air in the pulmonary parenchyma is highly irregular during the initial phase of neonatal adaptation Many alveoli and alveolar duct remain unexpanded during the first two hours of extra uterine life not to be aerated until the age of 4 to 6 hours (KIKKAWA et coll 1968 GROSSMANN & ROBERTSON 1974) This irregular expansion with air trapping in preterminal airspaces is natural in a partially fluid filled parenchyma, where the distribution of air is influenced by surface forces Later on as the fetal pulmonary fluid becomes resorbed and the surface forces in the alveolar lining layer are more effectively balanced by surfactant phospholipids, the expansion of the lung becomes regular and the alveoli polygonal Our morphometric data indicate that the aeration of the parenchyma goes with a considerable increase in the relative volume of the alveolar compartment In other words, the lungs of the rabbit fetus do not seem to be fully expanded at term (cf ADAMS et coll 1969)

Third there is a remarkable fall in the wet weight of the rabbit lungs during the first two hours of extrauterine life This observation agrees with the data presented by AHERNE & DAWKINS (1964) Apparently the removal of fluid from the lungs does not begin until after 15 min of age i e at a stage where—according to our morphometric calculations—the postnatal expansion of the alveolar compartment has already taken place Our morphometric calculations and lung weight recordings do not however permit any conclusions as to the ratio between intraalveolar and interstitial pulmonary fluid The swelling of perivascular fibrous tissue that is frequently observed in lung sections from fetuses killed during the early phase of neonatal adaptation suggests that there is an accumulation of fluid in the interstitial spaces of the lungs shortly after the onset of breathing (AHERNE & DAWKINS) In our morphometric calculations such a swelling of the interstitial tissues would cause a trend towards under estimation of the postnatal expansion of alveoli It will to some extent mask an increase in the volume of the alveolar spaces by increasing the denominator of the alveolar expansion index

There is a discrepancy then between the roentgenographic impression of an almost complete aeration of both lungs within a few seconds after the onset of breathing and the microscopic findings and lung weight recordings which both indicate that the aeration of the pulmonary parenchyma is protracted over a period of many hours The roentgenologic technique used is obviously less sensi

tive than the other two methods for determination of the fluid component of the lungs and the recognition of irregular air distribution, air trapping, and foaming is limited by the maximal resolving power of the roentgen recording system. Apparently the radiologic impression of almost complete aeration can be achieved by inflation of the lungs with a volume of air which is less than the residual capacity that will normally develop during the subsequent hours of extrauterine life (cf. KARLBERG 1960).

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SUMMARY

The lungs of fullterm newborn rabbit fetuses were examined with roentgenologic and histologic techniques. Roentgenologically there seemed to be an almost complete aeration of the lungs already within a few seconds after birth. The microscopy, however, revealed that the initial lung aeration was irregular; many alveoli remaining fluid filled even after two hours of breathing. Apparently roentgenology fails to recognize the irregular aeration which characterizes the lung parenchyma in the early period of neonatal adaptation.

ZUSAMMENFASSUNG

Die Lungen ausgetragener neugeborener Foetusse des Kaninchen wurden mit röntgenologischer und histologischer Technik untersucht. Röntgenologisch scheinen die Lungen bereits innerhalb von einigen Sekunden nach der Geburt vollständig mit Luft gefüllt zu sein. Die histologische Untersuchung ergab jedoch, dass der initiale Luftgehalt der Lungen unregelmässig war; viele Alveolen verblieben flüssigkeitsgefüllt, noch nach zweistündiger Atmung. Offensichtlich vermögen die röntgenologischen Untersuchungen den unregelmässigen Luftgehalt festzustellen, der das Lungenparenchym in der frühen Periode der neonatalen Adaptation kennzeichnet.

RÉSUMÉ

Les auteurs ont examiné par des techniques radiologiques et histologiques les poumons de fœtus de lapins nouveau-nés à terme. Radiologiquement il paraît y avoir une aération effective complète des poumons dès les premières secondes après la naissance. L'examen histologique cependant a montré que l'aération initiale du poumon est irrégulière; de nombreux alvéoles étant remplis de liquide même après deux heures de respiration. Apparemment l'examen radiologique ne permet pas de reconnaître l'aération irrégulière qui caractérise le parenchyme pulmonaire au cours de la première période d'adaptation néonatale.

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HEREDITARY HAEMORRHAGIC TELANGIECTASIA OF THE LIVER DEMONSTRATED ANGIOGRAPHICALLY

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Hereditary haemorrhagic telangiectasia or Osler-Weber-Rendu syndrome is a familial disease characterised by telangiectasia of the mucous membranes and skin. Clinically it usually presents with recurrent or gastro-intestinal bleeding. The arteriovenous malformations may be widespread throughout the body and involve the central nervous system, the lungs, the liver and urinary tract (RENDU 1896, PARKES WEBER 1907, OSLER 1907, BURCHELL & CLAGETT 1947, SMITH & LINEBACK 1954, ALEXANDER & HARRINGTON 1955, MICHAELI et coll. 1968). Rarely the arteriovenous malformations may cause enlargement of an abdominal organ.

In some organs the arteriovenous fistulae are demonstrable by angiography enabling their full extent to be more accurately defined than by clinical assessment alone.

The angiographic appearances of hereditary haemorrhagic telangiectasia of the lungs are well known (BURCHELL & CLAGETT; RAVINA 1949, BRINK 1950, HEDINGER et coll. 1951, KUSHLAN 1951, ALEXANDER & HARRINGTON, HODGSON

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Fig 1 Microph tograph of biopsy specimen of liver showing dilatation of the sub lobular portal tracts and central eins nd angiomatoid nous spaces

et coll 1959 Moyer et coll 1962 Chandler 1965) There has been a report of the lesions demonstrated by cerebral angiography (Chandler) The liver lesions have also been demonstrated by arteriography (Rannioer & Odman 1963 Michaeli et coll 1968 Halpern et coll 1968 Razi et coll 1971 Farrell et coll 1972 Kinkhabwala et coll 1972)

This paper describes the findings on hepatic angiography performed to investigate the cause of hepatomegaly in a patient with hereditary haemorrhagic telangiectasia The differential diagnosis is discussed

Case report

A 41 ear old oman known to have hereditary haemorrhagic telangiectasia was admitted for hepatic angiograph to investigat the cause of hepatomegaly She had telangiectasia of the lips and finger tips Her father had imilar lesions and had suffered from ecurrent epista es

The patient had 10 year history of d spepsia and diagnosis of chronic duodenal ulcer had been mad by barium meal Four ears befor the angiography she had had chol cystectomy for gallstones and agotomy and pyloroplasty because f worsening peptic symptoms At laparotomy the liver and spleen wer slightly enlarged The liver was finely nod la And there ere dilated eins in th portal system

A liver biopsy show ed increased fibrosis around the bil ducts and in the portal tracts but there w no evidence f established cirrhosis and the parenchymal cells ere normal

Three years befor the present admission she had hysterectomy for menorrhagia and test ursted liver d function Tw months before th present admission she dev loped obstructiv j undice hich as due to stones in the common bil duct The bile duct was explored and the tones remov ed

At this laparotom the coeliac axis nd ts branches wer observed t be ery dilated and



Fig Prone flood aortogram) Arterial phase Diameter of coeliac axis is pproximately as great as that of the aorta Early filling of hepatic ein radicles (→) and contrast pooling (↔) b) Hepatographic phase Irregular nodules are contrast outlined and the normal homogeneous hepatographic ppearance absent

tortuous w th palpable thrill A liver biopsy was again taken The histology showed dilata tion of the sub lobula portal tracts and central eins producing in some areas angiomatoid cystic enous dilatation The branches of the hepatic artery were dilated Th appearances were considered typical f the telangiectatic lesions f Osler s disease (Fig 1)

Hepatic angio phy Attempts at selectiv catheterisation of the coelia axis and hepatic artery proved impossible Instead flood aortic injection f 80 ml Conra 420 as mad ith the patient prone A series of films f th hepatic egion were taken with an AOT film hanger

The examination shov ed that th coeliac axis was enormously dilated its diameter being bout as great as the aort The hepatic artery and its branches were also extremely dilated and tortuous indicating ery greatly increased blood supply to th liver The flow f the contrast medium through th hepatic artery as ery fast with early filling of eins (Fig)

I the hepatographic phase numerous diffusely scattered pools f contrast medium 1 to cm in size were shown (Fig 2 b)

Discussion

Hepatic angiography is best carried out by selective catheterisation using a preformed catheter introduced from the femoral artery. As a single hepatic artery arises from the coeliac axis in only 55 per cent of patients (STULBERG & BIERMAN 1965), satisfactory selective studies often require catheterisation of both coeliac axis and superior mesenteric artery; the otherwise underfilled areas of the liver may be confused with avascular lesions. If such selective catheterisations prove technically impossible, as in this patient, a prone flood aortogram using a large volume of contrast (80 to 100 ml) is a reliable alternative. As contrast is heavier than blood (KJELLBERG 1943), in the prone position the anteriorly placed coeliac axis and superior mesenteric arteries are preferentially demonstrated.

In the differential diagnosis of the angiographic appearances of Osler's disease of the liver the most important lesions to be excluded are primary hepatoma, hepatoma arising in a cirrhotic liver, metastases, and cavernous haemangioma, as these show increased vascularity. A primary hepatoma usually appears angiographically as a highly vascular solitary mass with small irregular areas of contrast pooling in the late phase of the examination. The main hepatic artery and its branches are usually enlarged. If the portal vein is shown to be involved by tumour the diagnosis of a hepatoma is virtually certain (BOIJSEN & ABRAMS 1965, BARTLEY et coll. 1967, ALFIDI et coll. 1968, TREDENS 1969, KREEL 1970).

A hepatoma in a cirrhotic liver shows similar features. However, such tumours may be multiple and the parenchymal pattern of cirrhosis is present. In cirrhosis the hepatic artery and its main branches are usually of normal size but the more peripheral branches are attenuated and tortuous. In the hepatogram there is diffuse fine mottling. Rarely a large regenerating nodule may show arteriovenous shunting like a hepatoma (FARRELL et coll.). This is however of minor degree and the bizarre irregular appearance of tumour vessels is never observed in cirrhosis alone.

Metastases also have a vascular supply but the hepatic artery is of normal calibre. Metastases often have a richer peripheral blood supply than a hepatoma, giving a dense outer margin to the lesions. They are usually multiple, clearly defined, variable in size and do not show arteriovenous shunting. Normal liver parenchyma is present between them (BOIJSEN & ABRAMS).

A cavernous haemangioma characteristically has a slightly dilated hepatic artery and crowded branches. Clearly defined pools of contrast persist for a considerable time after injection (KREEL).

In hereditary haemorrhagic telangiectasia, because the arteriovenous malformations are so widespread, the hepatic artery and its branches may reach an

enormous size (MICHAELI et coll) This was so in our patient (Fig 2 a) We consider this to be an important diagnostic feature as in no other condition does the arterial supply to the liver become so great Early filling of hepatic veins and venous pooling (Fig 2) are the other features of this disease (MICHAELI et coll HALPERN et coll) The normal homogeneous pattern of the hepatogram is obscured This is replaced by ill defined nodules up to 2 cm in diameter No typical tumour circulation is seen The lesion of Osler's disease is in fact a capillary angiodysplasia

When a patient with Osler's disease develops hepatomegaly the cause may be due to either involvement of the liver by telangiectasia, cirrhosis from repeated blood transfusion given for haemorrhage or an entirely unrelated cause Thus in the management of such a patient hepatic angiography may be helpful in confirming the diagnosis of hereditary haemorrhagic telangiectasia of the liver and excluding other diseases

This report is presented to draw attention to the angiographic appearances of the liver in Osler Weber Rendu syndrome

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SUMMARY

The angiographic appearances of the liver in patient with hereditary haemorrhagic telangiectasia are presented and the differential diagnosis discussed.

ZUSAMMENFASSUNG

Das angiographische Bild der Leber bei einer Patientin mit hereditärer hämorrhagischer Teleangiektasie wird dargestellt und die Differentialdiagnose diskutiert

RÉSUMÉ

Description des aspects angiographiques du foie chez un malade atteinte de telangiectasie hémorragique héréditaire et discussion du diagnostic différentiel

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SOFT TISSUE RADIOGRAPHY OF FINGER JOINTS

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Soft tissue changes constitute a prominent feature in rheumatoid arthritis giving rise to the typical spindleshaped appearance of the fingers involved (Ragan 1967) Periarticular swelling has been reported to be the earliest roentgen sign in this region (Smyth 1967) although it has apparently been observed in standard as opposed to special soft tissue films The present communication deals with the finger joint appearances when examined with a technique similar to that used in the examination of the female breast A description of the roentgen appearances of the normal and arthritic conditions will be supplemented by certain aspects of the technique

Material and Methods The material consisted of three groups The first of these comprised 20 women with rheumatoid arthritis and aged between 19 and 74 years in 17 of these the diagnosis was confirmed by serologic tests whereas in the remainder the serology was unknown The clinical and roentgenographic appearance indicated rheumatoid arthritis The disease was more or less advanced but without crippling deformities or generalized ankylosis Considerable

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b

Fig. 1. Metacarpophalangeal joints of left hand. a) Control. b) Female with rheumatoid arthritis. Dig. 2 is the right extreme in both films; wedge-shaped pad of fat between the joints in (a) partially blurred in (b) owing to soft tissue swelling around the joints of digs 2 and 3. No swelling around the joint of dig. 4. Sharp boundary of soft tissue swelling at the radial aspect of the dig. 2 joint (→).

differences existed within the group as regards the degree of rheumatic activity; all patients in this group had been treated for a considerable time. The second group consisted of 11 patients, 6 males and 5 females aged between 18 and 62 years, suffering from miscellaneous conditions, some with Heberden's nodes and others with early arthritis of uncertain type. The third group was made up of 15 control patients, 7 females and 8 males aged between 19 and 74 years. None of them displayed any symptoms or signs of disease of the finger joints.

The technique was not uniform in that the experiences as gained were immediately converted into improvements. Certain aspects of the choice of roentgen tube, of the projections, and of the positioning of the patients will consequently be presented as part of the results.

All recordings were made on industrial non-screen film Agfa/Gevaert Mamoray 2, developed in a roll machine in 6 min (DEICHGRÄBER et coll. 1974), developer Agfa/Gevaert G 122, fixer Agfa/Gevaert G 322. Two types of roentgen apparatus were used: one was a Siemens Mammomat equipped with a molybdenum target roentgen tube and a molybdenum filter as described by GROS (1967), tube potential 35 kV. The second apparatus consisted of a skull board fitted with a tungsten rhenium target roentgen tube with a tube window of an absorption equivalent to that of 0.5 mm Al; no additional filtration was used. A six valve generator was used at a tube potential of 26 kV, this value being ascertained by direct measurements. Higher potentials —up to 40 kV—were employed only occasionally.



Fig 2 a) Joints of the thumb in control case b) Metacarpophalangeal joint of a female with rheumatoid arthritis Soft tissue swelling on lateral aspect of joint

The projections consisted of one perpendicular to the hand and one or two oblique projections The lateral projection was discarded after preliminary testing owing to the length of exposure time The roentgenograms of the control group were inspected first after which the different types of soft tissue changes and skeletal changes were tabulated for all finger joints of the subjects with disease As the technique was altered during the investigation the frequency of the different changes will not be mentioned this scrutiny merely served the purpose of making the authors familiar with the possible variations Only one factor will be discussed the degree of correlation between skeletal and soft tissue changes

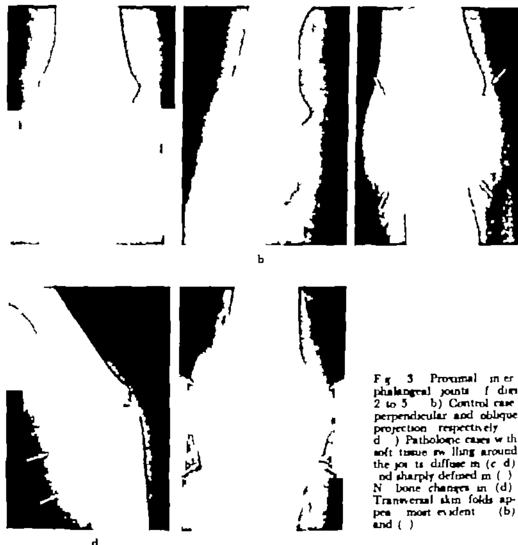
No attempts were made to correlate the radiographic findings with the clinical state of the patients

The roentgen exposure and the spectral distribution of the radiation were determined for the method considered best from a clinical point of view The exposure rate at a given point in the roentgen radiation field may be expressed

$$X = a\frac{Ii}{r^{2}}$$

where I is the total relative intensity calculated from the mathematic model (STRID 1972 STRID & LANTZ 1973) i the roentgen tube current r the distance from the tube focus to the point and a a universal constant The exposure measurements (LANTZ & STRID 1973) indicated that $a \approx 0.10$ mR m^{2} s^{-1} mA^{-1}

Most of the roentgenograms were obtained with a tungsten tube operating at 26 kV the target-object distance being 66 cm at 130 mAs For 26 kV tungsten



F g 3 Proximal in er phalangeal joints f digits 2 to 5 b) Control case perpendicular and oblique projection respectively d) Pathologic cases w th soft tissue sw lling around the joi ts diffuse in (c d) nd sharply defined in ( ) N bone changes in (d) Transversal skin folds appea most evident (b) and ( )

radiation filtered through 0 5 mm aluminium and 66 cm air *I* was calculated to be 15 9 the object was thus exposed to c 0 47 R for each roentgenogram

Results

The metacarpophalangeal joints of the 2nd to 5th fingers are surrounded by the interosseou and lumbrical muscles between the heads of which usually lies a wedge shaped pad of fat tissue (Fig 1 a) The presence of mu cle tissue



Fig 4 Distal interphalangeal joints of digs 2 to 5) and b) The normal joint ppearances in different projections) and d) Diffuse soft tissue swellings but no sk letal changes in (d)

often masked the joints in the early stages of a disease so as to raise doubt as to whether a soft tissue swelling existed or not This obstacle was however largely overcome in muscular atrophy (Fig 1 b) Atrophy was discernible as a general reduction in the roentgen absorption in conjunction with infiltration of fat in the muscles the fat pads also grew broader in muscular atrophy so that the periarticular reactions were more easily demonstrable in patients who had been suffering from arthritis for some years The contribution of a soft tissue technique to the early diagnosis of arthritis in the joints thus appears to be limited although as will be discussed later reason seems to exist to expect that this technique even in chronic cases may prove valuable

The soft tissue changes in the metacarpophalangeal joints other than those of the thumb mainly consisted of diffuse oedematous infiltration (Fig 1 b) Only rarely were such sharply limited areas of infiltration as will be described below for other joints evident (Fig 1 b) The metacarpophalangeal joint of the thumb is largely covered by the thenar muscles The capsule on the dorsal aspect of the joint lies however close to the subcutis (Fig 2 a) which makes its examination easier Periarticular oedema was again a prominent feature (Fig 2 b)

The interphalangeal joints of the 2nd to 5th fingers seemed to lend themselves to accurate soft tissue examination A thin stripe of fat tissue was normally evident on each side of the joint (Fig 3 a b) while proximally and distally to



Fig 5 Proximal interphalangeal joints of digs 3 (to the right) and 4 in advanced rheumatoid arthritis Joint surfaces totally destroyed in both joints soft tissue reaction in dig 3 but not in dig 4

the joint these stripes usually widened The skin folds on the dorsal aspect of the joints often resembled an articular swelling Two main abnormalities were recorded One—the more common—was diffuse periarticular oedema (Fig 3 c) this was easily detectible, giving the impression that early and accurate diagnosis of arthritis might be possible In fact, two patients in the miscellaneous group displayed such soft tissue swelling without any skeletal changes (Fig 3 d) The second roentgen sign of joint abnormality consisted of a sharply demarcated area of increased periarticular roentgen absorption (Fig 3 e) Whether this was also due to oedema or if some other abnormality such as periarticular fibrosis was present was not obvious

The distal joints of the 2nd to 5th fingers were generally not surrounded by the same amounts of fat tissue as the proximal joints of the same fingers This was specially so in the projection perpendicular to the hand (Fig 4 a) while the oblique projections disclosed more of the borders of the joint capsule (Fig 4 b) It was consequently somewhat more difficult to demonstrate the existence of minor degrees of oedematous infiltration Fig 4 c and d illustrates two distal joints with marked periarticular oedema One of these was of a woman with a seropositive rheumatoid arthritis the other a woman with arthritis of unknown aetiology but no skeletal changes Increased roentgen absorption of the soft tissues around the joints with advanced changes of the Heberdeen type was also present

The projections used presented the interphalangeal joint of the thumb more or less from the side (Fig 2 a) this did not interfere with the interpretation however as the images were similar to those of other finger joints with arthritis

One striking feature was the absence of correlation between the soft tissue and skeletal changes Joints without the latter might display obvious soft tissue

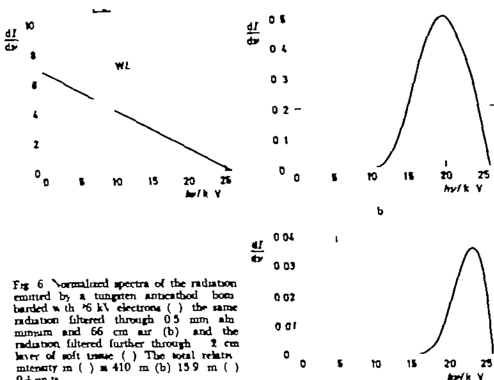


Fig 6 Normalized spectra of the radiation emitted by a tungsten anticathode bombarded with 26 kV electrons ( ) the same radiation filtered through 0 5 mm aluminium and 66 cm air (b) and the radiation filtered further through 2 cm layer of soft tissue ( ) The total relative intensity in ( ) is 410 in (b) 15 9 in ( ) 0 4 units

signs of disease (Figs 3 d 4 d) On the other hand those with advanced destruction might be combined with any degree of soft tissue changes (Fig 5)

Both types of roentgen apparatus produced acceptable roentgenograms although the skull board with the tungsten target tube was preferred for several reasons The fact that the molybdenum tube gave inconveniently high contrast tended to underexpose thick fingers and overexpose slender fingers moreover the skeleton was sometimes difficult to define making special skeletal films necessary All these disadvantages were acceptably eliminated with the tungsten tube operating at 26 kV while the reduction in contrast failed significantly to impair the examination of the soft tissues The impression was gained that the potential of a tungsten tube should not be allowed to rise much above 26 kV since the perception of fine soft tissue detail is then rendered increasingly difficult The first cases were examined at 40 kV a potential that was subsequently regarded as completely unsuitable Only a vague outline of the joint capsules could then be perceived (Fig 3 d) The conclusion was thus drawn that although

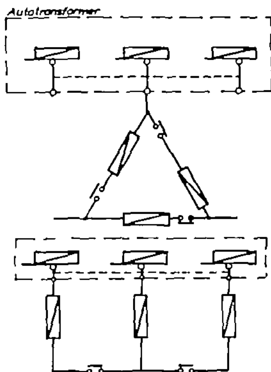


Fig. 7. Wiring diagram of simple means of modifying standard delta connected generator (top) into a star connected generator (bottom) reducing the tube potential by a factor of $\sqrt{3}$. 40 kV with the delta connected transformer is reduced to 23 kV.

a tungsten target seems preferable to a molybdenum one, a special tube with low inherent filtration is still needed for use at the lower potentials. Standard roentgen tubes and unadapted generators seem to be unsatisfactory for the present purpose.

Three projections proved to be preferable: one perpendicular to the hand and two oblique. It was apparent again and again that the demonstration of only slight periarticular changes indicated simultaneous scrutiny of all three projections. The accomplishment of the oblique projections turned out to be problematic however. The roentgen beam could with the Mammomat not be angled and the hand had to be turned instead. The rheumatic condition of the patients in combination with long exposure times produced however disturbing movement unsharpness more often than was acceptable as most fingers had to be left without support. Stabilizing devices invariably appeared in the roentgenograms and impaired the image quality. The skull board enabled the problem to be solved by angling the beam 30° to either side without moving the film or the hand that rested upon it. This procedure gave rise to lateral distortion which although it failed to disturb interpretation also produced an increase in geometric un-

sharpness thus becoming barely tolerable The FFD was 68 cm and the focus size for the actual tube load 0 7 mm × 1 0 mm The focus measurement was made according to the DIN procedure except for the tube load Angulation of the tube in the direction of the smallest focal dimension proved to be preferable Since the smallest dimension of a focus is generally directed at right angles to the longitudinal axis of the tube, the latter should be angled in a direction perpendicular to its long axis and not in the direction of the axis as is usual in most installations

The roentgen spectrum was calculated by a mathematic model (STRID 1972 STRID & LANTZ 1973) The radiation reaching the object from a tungsten target bombarded with 26 kV electrons consists mainly of photons with energy in the range 15 to 25 keV (Fig 6) A soft tissue layer 2 cm thick absorbs 97 5 per cent of the radiation energy entering it The linear extinction coefficient of soft tissue was calculated to be 1 0 cm^{-1} for 25 keV photons and c 5 × 10 cm for photons of c 0 5 keV Thus from the physical point of view the contrast due to variations in the soft tissue attenuation is far from optimal with 26 kV radiation Clinical experience however indicates that increased physical contrast does not necessarily imply improved visibility

Discussion

Soft tissue examinations of the finger joints require special equipment Experiences suggest that the skull board or any similar apparatus with which the roentgen beam may be conveniently angled is best The tube should have a tungsten target a low degree of inherent filtration and a potential of about 26 kV Most clinics possess a skull board or a similar device but the tube and the generator are usually unsuitable for soft tissue The suggestion is made that next time the tube is changed one of low inherent filtration such as Siemens Bi 125/30/50 MaR be installed All types of conventional radiography may with additional filtration, be performed with such a tube The problem of the generator remains The present authors modified a standard transformer so that it could be used for conventional potentials (40 to 120 kV) as well as for lower voltages (23 to 40 kV) A wiring diagram of the modified generator—a Triplex Optimatic 1023 m from Elema Schonander—appears in Fig 7 It is suggested that if a skull table is to be adapted to soft tissue radiography the manufacturers of the equipment should be asked whether it is possible to modify the generator at the same time

The present report indicates that soft tissue roentgenography may contribute to the clinical handling of conditions of the finger joint Two aspects seem to merit further attention One is the question whether this can provide earlier

diagnosis of arthritis than is possible today. The other is the problem whether there is justification for assuming that the state of the soft tissues directly reflects the activity of the disease, regardless of the degree of skeletal changes. These problems require further investigation.

SUMMARY

Finger joints have been examined roentgenologically with a soft tissue technique at a relatively low kilovoltage. Particular attention has been directed to modification of the equipment. Soft tissue films appear to enhance the value of the examination of these joints and to supplement the routine roentgenograms of the bones.

ZUSAMMENFASSUNG

Fingergelenke wurden röntgenologisch mit einer Weichgewebetechnik bei einem relativ niedrigen Kilovoltwert untersucht. Besonderer Wert wurde auf eine Abänderung der Anordnung gelegt. Weichgewebe Filme scheinen den Wert der Untersuchung dieser Gelenke zu erhöhen und die Ergebnisse der Routineröntgenbilder der Knochen zu ergänzen.

RÉSUMÉ

Les articulations digitales ont été examinées radiographiquement par une technique de parties molles avec un kilovoltage relativement bas. Les auteurs se sont attachés particulièrement à la modification de l'équipement. Les films pour tissus mous paraissent augmenter la valeur de l'examen de ces articulations et compléter les radiographies ordinaires du squelette.

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HOMOGENEITY OF INTENSIFYING SCREENS

S Reichmann and C G Helander

The quality of the screen film combination greatly influences the total noise level of a radiographic system First of all the sensitivity determines the roentgen dose and thus also the quantum mottle, so that high sensitivity makes for high quantum mottle This is universally recognized However little information has been published as to whether the crystal structure of the screens introduces structure mottle to such a degree as to be harmful in everyday routine work Cleare et coll (1962) stated from experiments that this was not so Reichmann (1974) in comparing two different screen film combinations observed that a considerable difference in noise could be discerned despite the fact that the combinations tested were of identical sensitivity The question thus arises whether the differences were due to variations in the homogeneity of the roentgen absorption of the screens Since Cleare et coll tested only one commercially available calcium tungstate screen—without mentioning the exact make—together with one specially made potassium iodide screen there appeared to be justification to revert to the problem somewhat more thoroughly

The influence of screen structure on image quality was investigated in two experiments one based upon the other

The first goal was to find out whether the absorption of commercially available screens was homogeneous or varied overall The following front screens were

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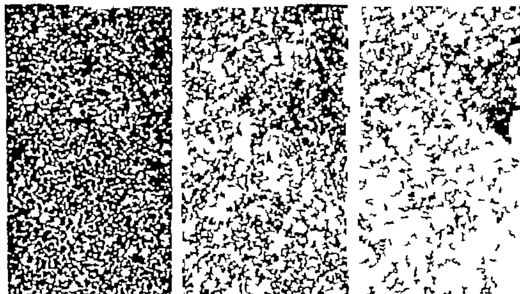


Fig 1 Roentgenograms of intensifying screens Dark reas in the image correspond to low roentgen absorption in the screen The structure is) coarse b) intermediat and) fine the screens belonging to categories I II nd III respectivel Magnification ×6 Th contrast has to he same degree been enhanced

tested by radiography Siemens Saphir Siemens Rubin, Cawo Universal Cawofin Philips Universal Du Pont Par Speed, Kodak X omatic Regular and Kodak X-omatic Fine The screen to be examined was placed upside down on a double wrapped industrial roentgen film (Agfa/Gevaert Mamoray T3) the film was thus blackened not by the light emitted by the screen but by the roentgen rays pa ing through it Tube potential was 23 kV tungsten anode The resulting roentgenograms displayed inhomogeneous blackening owing to the crystal structure of the screens The mottle thus recorded suggested that the screens could be divided into three groups (Fig 1) The first of these had the most obvious mottle The following screens belonged to this category Siemens Saphir Siemens Rubin Cawo Universal Cawofin and Philips Universal The Du Pont Par Speed screen constituted the second group with a omewhat lower mottle The Kodak X-omatic screens—forming the third group—turned out to have remark ably low mottle (Fig 1 c) no clear difference was evident between the two screens in thi group

Types of experiments mentioned by CLEARE et coll were next used to deter mine how much the inhomogeneities influenced the final noise level The screens



Fig 2 Roentgen image formed with a screen belonging to category I (coarse crystal structure) the same as in Fig 1 a) The coarse inhomogeneities of the blackening constitute the mottle the structure mottle predominated over the quantum mottle Magnification ×6 The contrast has been enhanced

were permanently glued into cassettes onto the front of which roentgen absorbing markers were fastened After development a film exposed within a cassette displayed an image of the markers against a grey background containing various noise levels Two exposures were made on every type of film for every screen with a tube potential of 60 kV The films were developed in a 90 second roll machine The following types were used Kodak RP/R Agfa/Gevaert Curix RP Kodak X-omatic General and Kodak Kodalith Ortho type III The last mentioned film is a photo-technical one of low sensitivity the others are conventional radiographic films Between these roentgen films the sensitivity factor is 2 so that RP/R is about 4 times faster than X omatic General After development the two films of each type were superimposed a procedure guided by the markers and the mottle examined If the pattern was identical in the two images so that they completely covered each other it was concluded that it was formed by structure mottle rather than pure quantum mottle It was doubtful in one instance whether the mottle pattern of the two films really was identical a subtraction image had to be made from the two films so that the structure mottle was eliminated

The following results were obtained Screens belonging to category I—having the coarsest structure—gave rise to structure mottle in all films (Fig 2) This mottle seemed to predominate over the quantum mottle The predominance was less marked with the film of the highest sensitivity The mottle had the same appearance as the one in the roentgenograms of the screens (Fig 2) In screen

category II—Du Pont Par Speed—structure mottle was visible in films of low sensitivity with high sensitivity the quantum mottle predominated In category III—the Kodak X omatic screens—no structure mottle could be detected in any film

Discussion

The structure of intensifying screens is of greater significance than seems to have been hitherto believed The clinical comparison by REICHMANN between a screen of category I (coarse structure) and one of category III (fine structure) clearly demonstrated that the noise level in the former can be so high as seriously to impair the depiction of faint but clinically important signals REICHMANN assumed that the X-omatic screens must have an improved capacity to absorb roentgen photons Such an assumption might suggest that the thickness of the absorbing layer must be extraordinary high The present investigation indicates however that the improvement is due to increased homogeneity of absorption, so that no roentgen photon can escape between the crystals of the fluorescent layer

The lower noise level of screens belonging to category III seems in fact to be a prerequisite for better image quality in some types of examination

An exceptionally low noise level is mandatory in specialized soft tissue radiography such as mammary radiography (DEICHGRABER et coll 1974) For this reason many prefer non screen industrial roentgen film for such examinations (EGAN 1964 GERSHON COHEN et coll 1970 DEICHGRABER et coll 1974) A screen technique has been attempted (PRICE & BUTLER 1970) but the resulting change in noise level was not thoroughly examined The high roentgen doses in these types of examination make it desirable that a screen technique will be developed to improve the absorption capacity of the recording medium Screens with a fine structure should be combined with a film of low or moderate sensitivity In this way both structure mottle and quantum mottle will be kept low It may be pointed out in this connection that the grain of the film also constitutes a kind of noise that cannot be ignored This problem will be treated in a later publication

About a decade ago high voltage technique utilising potentials up to 200 kV was tested It seems now to have been abandoned however the general reason for this being the low contrast This means that so many signals were brought under the noise level of the roentgen system that the images were regarded as unacceptable However the introduction of screens with a low structure mottle may offer new possibilities in high potential radiography The hypothesis is this Fine-structure screens are combined with a suitable film so as to give an optimal

structure mottle, quantum mottle and film grain mottle the lowered signal in tensity in high potential radiography is then compensated for by a lowering of the noise level so that the signal/noise ratio remains unchanged

SUMMARY

The crystal structure of intensifying screens has been investigated A coarse structure will impair the image quality owing to increased noise termed structure mottle Screens of ery fine structure hav recently been introduced some new applications for such screens ar discussed

ZUSAMMENFASSUNG

Die Kristallstruktur on Verstarkerschirmen wurde untersucht Eine grobe Struktur er schlechtert die Bildqualitat infolge des erhohten Rauschens Struktur Fleckigkeit benannt Schirme mit sehr feiner Struktur sind kurzlich introduziert worden einige neue An wendungen fur diese Schirme werden diskutiert

RÉSUMÉ

Les auteurs ont etudie la structure cristalline des ecrans renforçateurs Une structure grossiere diminue la qualite de l image du fait d l augmentation du bruit de fond appelee granularite structurale Des ecrans d structure tres fine ont et recemment introduits les auteurs examinent quelques nouv lles applications d ces écrans

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ABSORBED GONAD AND INTEGRAL DOSES TO THE PATIENT AND PERSONNEL FROM ANGIOGRAPHIC PROCEDURES

J KAUDE and G SVAHN

Two reasons in particular initiated the present investigation The steadily increasing number of angiographic examinations (STIEVE 1969) and our relative lack of knowledge of doses delivered to the patient and personnel from angiographic procedures In Sweden measurements of gonad and integral doses to the patient have been reported in only a few angiographic examinations (LARSSON 1958 CARLSSON 1965) Other measurements, some of which include doses to the personnel are limited to cardiac examination (GOUGH et coll 1968 ARDRAN et coll 1970 1973 HAWKINS et coll 1970 MALSKY et coll 1971 WOLD et coll 1971) or to cerebral angiography (BERGSTROM et coll 1972)

Diagnostic equipment and technique Cardioangiography was performed with Siemens biplane equipment two 25/15 cm image intensifiers with automatic brightness control for fluoroscopy (exposure rate 20 respectively 40 μR/s on the

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Table 1

Gonad and integral doses from abdominal angiography in adults (gonads not shielded)

	No of measurements	Gonad dose mrad		Integral dose (kg rad)	
		Range	Mean	Range	Mean
Fluoroscopy	8	< 2–110	31	1–92	33
Serial radiography	8	80–160	114	57 443	140
Total dose	16	7–470	143	87 535	173

8 measurements

input screen) 70 mm cameras for serial fluorography (film rate up to 6 frames/s automatically controlled exposure 100 μR/frame on the input screen) 35 mm cine cameras, usually operated at 75 frames/s (exposure 20 μR/frame) Serial radiography was performed with Elema Schonander 35 cm × 35 cm cut film changers at a rate of up to 6 films/s (exposure to the film 1 2 mR not automatically controlled)

The focal spot size was as follows overhead tube for fluoroscopy and filming 0 6/1 0 mm overhead stereo tube (used in most abdominal angiographies) 1 0 mm and the tube in horizontal beam 0 3/1 3 mm The overhead fluoroscopy tube was shielded with lead rubber drapes

The total time for fluoroscopy in abdominal angiography varied between 3 and 57 min (mean 29 min) In cardiac examinations of adults the fluoroscopy time was between 5 and 43 min (mean 19 min) and in children between 3 and 39 min (mean 16 min) The total time for biplane cinefluorography varied between 13 and 40 s Fifty to 315 70 mm fluorograms and 17 to 94 full size films were exposed per examination

In abdominal angiography the 30 cm × 30 cm field size with stereo tube was used at least in one series Otherwise at filming and at fluoroscopy the primary diaphragms were carefully collimated

The film material used was as follows Gevapan 36/19? for 35 mm cinefluorography Gevaert Scopix HD for 70 mm fluorography and DuPont D4 or CEA film with Siemens Special intensifying screens for serial radiography The films —with exception for obese patients—were obtained at 90 kVp or lower

Material and method of measurements Gonad or integral doses to the patient were measured in 60 examinations—16 abdominal and 12 cardioangiographies in adults and in 32 cardioangiographies in children (age 15 years or less) Abdominal angiographies in children were not performed during the period

Table 2

Gonad and integral doses from bi plane cardioangiography in adults

	N of measurements	Gonad dose (mrad) Gonads shielded Range	Mean	Gonads not shielded Range	Mean	No of measurements	Integral dose (kg rad) Range	Mean
Fluoroscopy	5	< 2		< 2 – 15	7	10	1 – 31	13
35 mm cine	4	< 2	2 0	2 – 10	6	8	7 – 43	22
70-mm fluorography	3	< 2		< 2 – 5	2	6	1 – 22	8
Serial radiography	4	< 2 – 7	2 0	4 – 100	27	8	4 – 45	23
Total dose*	5	< 2 – 7	4	6 – 108	42	10	17 – 101	58

*Not all methods of filming used in every patient

Table 3

Gonad and integral doses from bi plane cardioangiography in children (0 – 15 years)

	N of measurements	Gonad dose (mrad) Gonads shielded Range	Mean	Gonads not shielded Range	Mean	Integral dose (kg rad) Range	Mean
Fluoroscopy	14	< 2 – 15	5 5			0 5 – 12	3
35 mm cine	8	< 2 – 8	4	Not separately determined		0 5 – 23	8
Serial radiography	9	2 – 9	5			3 5 – 11	7
Total dose	12	3 – 27	13	12 – 900	280	1 – 49	16

(m surements

I some patients onl one meth d of filming used

At 47 examinations, doses to the personnel (radiologist, radiology technician, cardiologist and pediatric nurse) were determined

Absorbed and gonad doses were measured with calibrated LiF thermoluminescent dosimeters Error in measurements was not more than 10 per cent with increasing accuracy for higher doses, and the lowest measurable dose was less than 2 mrad

For measurements of gonad dose in male patients, the dosimeters were placed on the testicles In females the doses in ovary region with dosimeters in the rectum were not measured as it was difficult to change them during the examination under sterile conditions In a number of cases the gonads of the patients were shielded by a 2 mm thick lead rubber

Absorbed doses to the personnel were measured with dosimeters on the third finger of both hands on the forehead and in the gonad region underneath the lead rubber apron (lead equivalent 0 5 mm)

During the filming, the radiologist, the technician and the cardiologist attending at heart catheterization left the examination room (exception coronary and small vessel angiography requiring manual injection by the radiologist) The pediatric nurse eventually holding the child stayed in the room as all examinations were performed without general anesthesia

Areal exposure (R $\times$ cm) was measured with light transparent, plane parallel ionization chambers (Pychlau Freiburg/Baden) The values were registered with an electrometer recorded graphically and integral doses in kg rad were calculated from the records (CARLSSON 1963 1964)

Results

The patient The highest gonad (mean 145 mrad) and integral doses (mean 173 kg rad) were delivered by abdominal angiography (Table 1) Of the total gonad dose as well as of the total integral dose approximately 20 per cent were contributed by fluoroscopy and 80 per cent by serial radiography In cardio angiography of adults 70 mm fluorography delivered lower gonad and integral doses than both serial radiography and 35 mm cinefluorography and contributed to the total dose even less than fluoroscopy Lead rubber shields reduced the gonad dose to approximately 10 per cent of that without protection (Table 2)

In cardioangiography of children approximately the same integral dose was contributed from both serial radiography and 35 mm cinefluorography 70 mm fluorography was not used in children The gonad dose with gonads shielded was approximately 5 per cent of that without protection (Table 3)

Table 4

Absorbed doses to the personnel from angiographic procedures (mrad)

	Radiologist						
	No of measurements	Middle finger				Eyes	Gonads
		Right		Left			
		Range	Mean	Range	Mean		
Abdominal angiography	8	< 2 – 33	11	< 2 – 112	26	Not measurable	Not measurable
Cardio-angiography (adults)	10	< 2 – 31	9	< 2 – 41	11		
Cardio angiography (children)	29	< 2 – 110	13	< 2 – 90	15	(< 2)	(< 2)

12 measurements

The personnel The mean absorbed dose to the middle finger of the radiologist varied depending on the type of examination between 9 and 26 mrad The highest dose—112 mrad to the left hand—was measured during abdominal angiography (Table 4)

The absorbed doses to the fingers of the pediatric nurse varied even to a greater extent depending on if the child had to be held during the examination or not The lowest absorbed dose was less than 2 mrad the highest 760 mrad, probably caused by direct irradiation of the fingers holding an infant during fluoroscopy and filming The mean absorbed dose to the right middle finger of the pediatric nurse was 75 mrad and to her left middle finger 89 mrad The mean absorbed dose to he eyes was 5 mrad per examination

The absorbed doses to the eyes of the radiologist to the fingers or the eyes of the cardiologist and radiology technician—both at a greater distance from the roentgen tube—as well as gonad doses to any of the attending personnel were not measurable i e they were less than 2 mrad per examination

Table 4 (*cont.*)

Pediatric nurse

No of measurements	Middle finger Right Range	Mean	Left Range	Mean	Eyes Range	Mean	Gonads
	< 2–40	7	< 2–760	89	< 2–11	5	< 2

Discussion

The patient In cardioangiography of children without gonad protection the absorbed dose to the gonads was high because of the short field gonad distance The exceptionally high dose in one case (900 mrad) indicates direct irradiation of gonads probably during fluoroscopy at catheterization In adults the mean gonad dose without gonad shield (42 mrad) was higher than the 25 mrad reported by Gouon et coll (1968) one of the reasons probably being that we used biplane cinefluorography and a higher frame rate

With the use of 70 mm fluorography in cardioangiography of the adults gonads not shielded the mean gonad dose was reduced to approximately 8 per cent of that in serial radiography The lowest gonad dose was found when gonads were shielded and recording systems from the output screen of the image intensifier were used The marked reduction of the gonad dose in both children and adults by shielding stresses the effectiveness of this simple protective measure It should be used in all examinations of children and of adults in fertile age including abdominal angiography if the shields do not interfere with the examination

The integral doses were highest in abdominal angiography They varied largely with the exposure rate time of fluoroscopy number of films and mainly with the field size In some cases, selective catheterization of sclerotic visceral arteries prolonged markedly the fluoroscopy time In fluoroscopy of the abdomen, the use of improved image intensifiers with automatic exposure control reduced the integral dose rate from 1 1 kg rad/min (KAUDE 1968) to 0 7 kg rad/min However the image intensifier television systems with automatic brightness control must be continuously tested for their function, and the radiologist must be aware of the potential dangers of increasing the exposure and dose rates with these units (STIEVE 1969)

Since our preliminary report on dose measurements in angiography (KAUDE et coll 1972) one patient received an integral dose as high as 535 kg rad This integral dose is approximately 50 times higher than that for examination of the upper gastrointestinal tract using video fluoroscopy and 70 mm fluorography (CARLSSON & KAUDE 1968) Although there are no recommendations by ICRP for permissible doses to the patient and there may be cases in which the diagnosis cannot be made without extensive angiographic examinations, the radiologist additionally to the use of automatic exposure controls, should always employ careful collimation, limit the fluoroscopy time and use proper filming programs to avoid unnecessary exposures Nevertheless, in teaching institutions the doses to the patient tend to be higher than in other departments of radiology as a relatively high number of diagnostically complicated cases are examined and because of teaching programs involved (CARLSSON 1965) The patient who received the integral dose of 535 kg rad was examined with repeated injections into the visceral arteries and serial radiography using stereo tube and 30 cm × 30 cm field size

Determinations of integral dose are important for epidemiologic investigations with special regard to the possible influence of the hematopoietic system from repeated small doses of ionizing radiation (NEBOSCHEW & SCHOTT 1959 GOLDMAN et coll 1960 CARLSSON 1965) Recently GIBSON et coll (1972) found evidence that there is an enhanced risk for males for myeloid leukemia from diagnostic radiology that this effect is more marked for irradiation of the trunk and increases with the number of films made GIBSON's report provides further support to the previous investigations on this subject (STEWART et coll 1958 1962) and stresses the importance of the use of examination techniques requiring a low exposure In examination of the gastrointestinal tract and in hysterosalpingography substituting 70 mm fluorography for ordinary radiography will yield a reduction of integral dose to approximately 13 to 30 per cent (BANG & KAUDE 1967 CARLSSON & KAUDE 1968) In cardioangiography of adults the use of 70 mm fluorography reduced the integral dose to 32 per cent

of that required for serial radiography although a larger number of films per examination were made with 70 mm technique As in certain angiographic examinations the image quality of 70 mm fluorograms is comparable with that of serial radiography the method should be used increasingly in cardioangiography and coronary angiography in which fluorography has the particular advantage of a short exposure time (BOIJSEN et coll 1969 KAUDE & HOLM 1971 PINET et coll 1971 HOLM & KAUDE 1972 KAUDE 1973)

In adults the integral dose ratio per film or frame was the same as the exposure ratio for the 3 filming systems used serial radiography 0 70 kg rad/film 70 mm fluorography 0 073 kg rad/film (exposure 1/10 of that required for serial radiography) 35 mm cinefluorography 0 013 kg rad/frame (exposure 1/50 of that for serial radiography) The total integral dose however did not decrease by a factor of 10 or 50 as more frames were made using serial fluorography or cinefluorography The integral dose from one minute videofluoroscopy (0 70 kg rad) was the same as from the exposure needed for one full size film

In children, the integral doses were lower because of lower exposure required and smaller field size The integral dose ratio however was approximately the same as in adults 0 15 kg rad/film in serial radiography and 0 0037 kg rad/frame in 35 mm cinefluorography (70 mm fluorography not used in children) The integral dose rate in videofluoroscopy was also lower (0 17 kg rad/min) but the ratio integral dose per full size film/one minute fluoroscopy remained 1 1 Thus it would be possible to perform one minute videofluoroscopy with the same integral dose as delivered by the exposure needed for one full size film As the new generation image intensifiers with cesium iodide input screen together with modern video tape recorders offer an excellent image quality considerable savings in dose would be made by substituting videofluoroscopy with simultaneous video tape recording for filming, at least in some examinations of the heart and great vessels

The personnel The dose to the eyes (forehead) of the radiologist from the undercouch tube in the report by WOLD et coll (1971) was 25 mR, and it has been postulated that the use of an overhead tube for fluoroscopy would increase the dose to the personnel and the patient (VIAMONTE 1971) In the present investigation the dose to the eyes of the radiologist from the overhead tube was not measurable Thus the installation of the roentgen tube above the patient did not result in higher doses to the personnel probably because we used lead rubber drapes at examination

In cardioangiography the absorbed doses to the fingers of the radiologist were higher than those to the wrist measured by ARDRAN & FURSDON (1973) Nevertheless they remained well below the permissible doses (75 rad) recommended by ICRP (1966) even if all angiographic examinations (in our

department some 1 500 per year) would be performed by the same radiologist.

We agree with ARDRAN & FURSDON that the doses determined by MALSKY et coll. (1971) were unnecessarily high and that—good examination technique and radiation protection provided—it is not necessary to rotate radiologists in cardiac (and neither in abdominal) angiography. In the practical work, anyway, not all angiographic examinations will be performed by one and the same radiologist.

The mean absorbed dose to the fingers of the pediatric nurse (right 75, left 89 mrad, the highest dose measured 760 mrad) makes rotation of this auxiliary personnel necessary in order to avoid their classification as radiologically employed personnel (permitted absorbed dose to the fingers for non-radiologically employed personnel is 7.5 rad per year, ICRP 1966).

Conclusions

With regard to the important, for the treatment of the patient often decisive, diagnostic information which can be obtained by angiography, a relatively high integral dose has to be accepted in some examinations. For reduction of the integral dose, the number of films should be limited, primary collimation carefully used and the time for fluoroscopy kept short. Further dose reduction is possible by substitution of serial fluorography or fluoroscopy with simultaneous video tape recording for other filming systems. The gonad dose to the patient can be reduced effectively by shielding. From radiation protection point of view there is no need to rotate radiologists performing angiography, the cardiologist attending or the radiology technician. A pediatric nurse holding a child during angiography should not participate at more than approximately 80 examinations per year. The use of an overhead tube for fluoroscopy and fluorographic recording does not result in excessive radiation of the personnel or of the patient. These conclusions are valid for the type of equipment and examination technique used in the present investigation.

Acknowledgement

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SUMMARY

Measurement of absorbed and integral doses to the patient and personnel from angiographic procedures are reported, the results are discussed and measures to reduce the dose suggested.

ZUSAMMENFASSUNG

Es wird uber die Messungen der absorbierten und Integral Dosen fur Patienten und Personal bei angiographischen Untersuchungen berichtet Die Ergebnisse werden besprochen und Massnahmen zur Herabsetzung der Strahlenbelastung werden vorgeschlagen

RÉSUMÉ

Les auteurs presentent les mesures de doses absorbees et de doses integrales au malade et au personnel au cours des examens angiographiques Ils examinent les resultats et proposent des mesures pour reduire ces doses

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RÖNTGEN AND THE NOBEL PRIZE

The discussion at the Royal Swedish Academy of Sciences in Stockholm in 1901

FOLKE KNUTSSON

The deliberations at the Academy of Sciences that led to the award of the first Nobel Prize in Physics to Wilhelm Conrad Röntgen in 1901 have previously been kept secret. Now that the minutes have been released, it has become possible to form an idea of how the most prominent scientists of the day in the field of physics assessed the significance of Röntgen's discovery.

Those authorized to propose candidates for the prize were the members of the Academy of Sciences and the Swedish professors of physics. A number of other authorities in the field of physics in different parts of the world had also been invited to proffer suggestions. When the time for nominations had expired 29 proposals had been submitted, 12 of them suggesting Röntgen, 1 Ph. Lenard and 5 a division of the prize between these two scientists. Nine other candidates were also mentioned, but each of these had only received one or at the most two votes. In consideration of the great variety of these suggestions the overwhelming majority for Röntgen was thus quite clear. It is especially interesting to note that the advisory committee of experts attached to the Academy, the Nobel Committee for Physics, recommended that the prize be divided equally between

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thus had had all the prerequisites enabling Rontgen to discover the new radiation

It is of interest to mention here an experiment which led to undoubted roentgen radiation but not to its discovery On 22 February 1890 Professor A W Goodspeed and a photographer named W N Jennings were carrying out photographic experiments at the institute of physics at the University of Pennsylvania in Philadelphia using as a light source the sparks in a vacuum tube After the developing work, they noticed a couple of very mysterious discs on a plate that had been lying in the room but had not been used No explanation of the phenomenon could be found The plate was saved Not until after Rontgen's discovery six years later did it become obvious that the picture was in reality a roentgen image and that its appearance was to be explained by the fact that two coins had been lying on the plate

At the time when Rontgen was awarded the Nobel Prize scientists in many parts of the world had for six years known about the discovery of the new form of radiation and they had realized that it would be of great significance to technical research and the medical sciences Although it was hardly possible at

that time to foresee the immense influence the discovery was to have on future developments it seemed quite natural that Rontgen should be proposed as a candidate for the Nobel Prize at the first conferment

W C Rontgen was one of the scientists who had been invited to submit names for the prize He suggested that Lord Kelvin (1824—1907) in Edinburgh would be a suitable candidate because of his extensive and important contributions in different fields in the science of physics The inquiry into his merits revealed however that his work had been carried out at such an early date that he could not according to the statutes be considered eligible

The Academy of Sciences is the authority that awards the prize in physics, and the Nobel Committee for Physics has the task of examining the proposals sent in and of presenting a suggestion as to a suitable prizewinner The Committee was composed of five members and during the discussions at its meetings it was decided that a division of the prize between Rontgen and Lenard should be recommended The two committee members Arrhenius and Ångstrom were instructed to draw up the reasons for this decision

Of the foreign experts who had been invited to propose candidates 12 had voted for Rontgen None of them had made an exhaustive assessment of the scientific purport of his discovery nor compared its significance with the results of other research work in progress in the field of physical science They considered quite simply that Rontgen s contribution was so well known that no further comments were needed and as a consequence their proposals were of no definite assistance as a guide for the Committee Lenard was proposed by S P Thompson in London who, in justifying his choice presented a detailed account of this scientist s work with cathode rays

The report presented by the Committee is given here in translation The italics have been added by Knutsson

To the Royal Swedish Academy of Sciences

After having examined the merits of the candidates proposed for the Nobel Prize in Physics for the year 1901 the undersigned members of the Nobel Committee for Physics of the Academy of Sciences have the honour to recommend that for the reasons given below the prize in question be divided equally between

Prof W C Rontgen Munich and Prof Ph Lenard Kiel

Stockholm 9 Sept 1901

C B Hasselberg
Knut Angstrom
Rob Thalen

H H Hildebrand
Svante Arrhenius

The scientific discovery which qualifies Professor Rontgen to a higher degree than others for selection at the first conferment of the Nobel Prize in Physics is so well known that a more detailed account of it would not seem to be necessary Professor Rontgen at the end of the year 1895 handed to the Wurzburger Phys Med Gesellschaft a paper entitled Über eine neue Art von Strahlen which was followed at the beginning of 1896 by another paper Eine neue Art von Strahlen II Mitteilung and in 1897 by still another Weitere Beobachtungen uber die Eigenschaften der X Strahlen These small treatises give an account of Rontgen s discovery of the rays to which he gave the name of X rays and they al o contain all the most important features of what is known today about this extraordinary phenomenon This discovery was of the greatest importance from the purely scientific point of view as it increased our knowledge by pre senting information on a phenomenon that hitherto has completely escaped our notice and has opened up a new field offering undreamt of possibilities for scientific research Its practical results also were of great importance It could therefore be said of this discovery with full justification that it has rendered the greatest service to mankind and that to award it the Nobel Prize would be fully in accord with the intentions of the founder

From this it also emerges that Rontgen s discovery is in our view of such great value that there would be every reason for awarding it the Nobel Prize without division

Nevertheless we take the liberty of recommending that the Nobel Prize in Physics be shared this year between Professors Rontgen and Lenard As will be een from the following arguments the latter through his investigations into the properties of the cathode rays paved the way for Rontgen s discovery and thereby made a purely scientific contribution of such importance that it is fully equal to Rontgen s observations which on the other hand surpass those of Lenard because of their practical applications When scrutinizing the merits of these two scientists we have found it difficult to decide which of them should be considered on the basis of their investigations the most worthy to receive the Nobel Prize in Physics if it were to be awarded to one of them alone and even more so as their discoveries are so intimately interconnected That opinions have previously on similar occasions been in agreement regarding the scientific equality of these two research workers is clear from the fact that the Academy of Sciences in Vienna in 1896 divided the Baumgarten Prize equally between them and that the Paris Academy in 1898 awarded two La Caze Prizes one to Rontgen and the other to Lenard

Already at an earlier date Crookes Hittorf and others had made a thorough study of the cathode rays but in their investigations the rays could only be examined in the actual discharge tube a procedure that obviously caused con

siderable difficulties Hertz, however demonstrated that cathode rays penetrate thin layers of metal and this observation caused Lenard to think that it might be possible to obtain cathode rays outside the discharge tube by arranging on the tube a window hermetically sealed by a membrane penetrable by these rays On 12 January 1893 Lenard handed to the Berlin Academy a preliminary report on his experiments, entitled Über Kathodenstrahlung in Gasen von atmosphärischem Druck und im äussersten Vacuum (Wied Ann 51 1894) This was followed by his doctoral thesis, Über die magnetische Ablenkung der Kathodenstrahlen (Wied Ann 52 1894) and by a third paper Über die Absorption der Kathodenstrahlen (Wied Ann 56 1895) In these treatises, which all preceded Röntgen's discovery Lenard demonstrated that cathode rays can be produced outside the discharge tube, and there he also investigated their leading properties He examined the absorption and diffusion ability of different bodies, demonstrated how cathode rays give rise to phosphorescence, and showed that the rays have an effect on a photographic plate even when it is protected from the influence of visible light He also proved that there are different types of cathode rays that these rays are influenced to different degrees by magnetic forces, and that their nature alters with the attenuation in the discharge tube furthermore he produced for the first time with the aid of a magnet a simple spectrum of the cathode rays *As Lenard had varied the pressure in the discharge tube from the most extreme attenuation when discharge is prevented to the highest degree of pressure there seems to be little doubt that he was already dealing with Röntgen's X rays although their differentiation from the cathode rays had escaped his attention The credit for their detection thus belongs to Röntgen It is obvious however that Lenard was very close to a discovery of the X rays and that he should undoubtedly be counted as Röntgen's most important forerunner* Professor Lenard subsequently continued his valuable investigations on the cathode rays and on questions connected with them A few of his other publications may be mentioned

Über die elektrostatischen Eigenschaften der Kathodenstrahlen (Wied Ann 64 1898)

Über das Verhalten von Kathodenstrahlung parallel zu elektrischer Kraft Wied Ann 65 1898)

Erzeugung von Kathodenstrahlen durch ultraviolettes Licht (Sitz ber d K Akad in Wien Okt 1899)

Über Wirkungen des ultravioletten Lichtes auf gasförmige Körper (Drudes Ann 1 1900)

Über die Elektricitätszerstreuung in ultraviolett durchstrahlter Luft (Drudes Ann 3 1900)

In view of the above arguments the proposal advanced here would seem to be fully justified

Comment

Thus the Nobel Committee, in its communication to the Academy of Sciences established that Rontgen's discovery provided knowledge about a previously unknown phenomenon had opened up a new field for research work and had had important practical results It also pointed out that the credit for the differentiation of the X rays from the cathode rays belonged wholly to Rontgen Because of the great significance of the discovery it undoubtedly deserved in the opinion of the Committee to be awarded an undivided Nobel Prize This was thus an unmistakable alternative to the suggestion as to division of the prize that was finally put forward by the Committee

The Committee had found that Lenard's systematic research into the properties of the cathode rays constituted a feat of such importance in itself that it was comparable to Rontgen's discovery and that in consequence it was hard to decide which of the two scientists should be preferred if the prize were to be awarded to one of them alone The choice was the more difficult because Lenard's research results had presumably been of considerable value in the experiments that led Rontgen to his discovery The Committee therefore considered *it necessary to stress that Lenard's work had paved the way for Rontgen's* experiments When this point had been made clear the natural consequence was to propose the alternative that the prize be divided between them

No minutes were kept at the meetings of the Academy of Sciences at which the Nobel Committee's proposal concerning the physics prize was discussed A wish that the prize should preferably be awarded to one candidate alone was obviously expressed during the deliberations, since according to a memorandum Arrhenius had remarked that Rontgen should be mentioned before Lenard At a meeting on 12 November 1901 the Academy in plenary session decided to award the prize to Rontgen The Academy thus disregarded the recommendation of the committee of experts Whether the Academy would have acted in a similar way today or would have followed the suggestion of the committee remains open for discussion It can however be established that no circumstances likely to be of significant assistance in simplifying this problem have come to light in the intervening period

The award of the Nobel Prize meant that Rontgen was honoured by a representative forum of the physical sciences Lenard (1862 –1947) the professor at Kiel felt that his work had been underestimated and took exception to the honour that had been paid to Rontgen He maintained that it was he who had been the first to observe the new form of radiation The opposition began in connection with the presentation of the Nobel Prize Previously fairly friendly relations had existed between the two men and no written criticism was advanced by Lenard Glasser has described Lenard's campaign after examining

the rumours that had been circulating and the written evidence available, and from a correspondence with Lenard in order to obtain information on the historical background Glasser concluded that there were no well founded motives to account for the hostile criticism directed against Rontgen Lenard however continued the controversy throughout the rest of his life, despite the fact that he was awarded the Nobel Prize in Physics in 1905 for his work on the cathode rays Even as late as in 1944 when he was 82 years old he reverted to the matter in a bitterly critical article in which he used a parable with the following import Rontgen was the assistant at the delivery and thereby was the first to be able to hold up the child for inspection Lenard, on the other hand was the mother who possessed the knowledge of all that had gone before

Lenard was not able to advance convincing arguments capable of discrediting Rontgen's achievement and thus did not succeed in depriving him of the credit for the discovery It is to be regretted that he never learned of the pronouncement made in 1901 by the experts on the Nobel Committee, pointing out that Lenard's research results must be acknowledged as being of such fundamental significance to the discovery by Rontgen that the physics prize ought to be divided equally between them As a consequence, he had no opportunity to make use of this opinion and thus missed having for his campaign a much more powerful argument than the unconvincing ones that were adduced

SUMMARY

The discussions carried on at the Swedish Academy of Sciences when the Nobel Prize in Physics was awarded for the first time in 1901 have hitherto been kept secret The Nobel Committee for Physics attached to the Academy consisting of five experts considered that among all the candidates proposed Rontgen and Lenard were the most worthy to receive the distinction and recommended that the prize be divided equally between them In the discussions at plenary meeting of the Academy the wish seems to have been expressed that the prize should if possible be awarded to one scientist alone and it was decided to give it to Rontgen for his discovery of the rays that bear his name Lenard who remained unaware of the recommendation made by the Nobel Committee that the prize be shared between him and Rontgen considered that Rontgen had been unjustly given the entire credit for the discovery For the rest of his life he maintained that the importance of his own contribution to the discovery had been undervalued

ZUSAMMENFASSUNG

Die in der Schwedischen Akademie der Wissenschaften geführten Diskussionen als der Nobelpreis fur Physik zum ersten mal 1901 zuerkannt wurde sind bisher geheim gewesen Das Nobelkomitee fur Physik das der Akademie zugehort und aus fünf Experten bestand beurteilt unter allen den vorgeschlagenen Kandidaten Rontgen und Lenard als die wurdigsten die Auszeichnung zu erhalten und empfahlen den Preis zwischen diesen beiden gleich zu

teilen In der Diskussion der Plenarsitzung der Akademie scheint der Wunsch ausgedruckt worden zu sein der Preis solle wenn moglich nur einem Wissenschaftler alleine zuerkannt werden und es wurd entschieden ihn Rontgen fur sein Entdeckung der Strahlen die seinen Namen tragen zu geben Lenard dem di Empfehlung des Nobelkomitees dass der Preis zwischen ihm und Rontgen geteilt erden soll unbekannt blieb sah an da s Rontgen die ausschliessliche Ehre fur die Entdeckung ungerechtfert gt zuerteilt orden sei Fur den Rest seines Lebens hob er hervor die Bedeutung seines eigenen Beitrags zur Entdeckung sei unterbewertet worden

RÉSUMÉ

Les discussions qui ont eu lieu l Academi Suedoise des Sciences quand le Prix Nobel de Physiqu a et attribue pour la lere fois en 1901 ont jusq maintenant et tenues secretes Le Comit Nobel pour la physique rattache l A demie compose de 5 experts considerant que parmi tous les candidats proposes Rontgen et Lenard etaient les plus disposes de recevoir cette distinction et recommanda que le prix fut divise egalement entr eux Au cours des discussions à la reunion pleniere de l Academ le oeux sembl avoir et exprime que le prix devait si po sibl etr attribue un ul savant et il fut decid de le donner Rontgen pour sa decouverte des ra ons qui portent son nom Lenard qui resta ignorant de la recommandation fait pa le Comit Nobel que le prix fut partage entre lui et Rontgen considera que tout le merit de la decouvert rait ete injustement attribue Rontgen Pendant tout le rest de sa ie il soutint que l importance d sa contribution personnelle la decouverte avait te sous estimee

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SELECTIVE PHLEBOGRAPHY OF THE PANCREAS

J GOTHLIN A LUNDERQUIST and U TYLEN

Angiography of the pancreas has solely been based on selective examination of the celiac and superior mesenteric arteries and their branches, since a method for venous approach has not been available Catheterization of the portal vein via the umbilical vein in adults is now an established method and at transhepatic cholangiography portal vein branches are often punctured

Using the umbilical vein approach of the portal vein in portography for liver metastases pancreatic veins were accidentally found available for selective catheterization This was the incitement for a planned investigation of the pancreatic vein now presented as a preliminary report

Anatomy The venous drainage of the head of the pancreas is constituted by four main veins forming two arcades one posterior and one anterior (Fig 1) The posterior superior pancreatico-duodenal vein drains the posterior arcade into the portal vein. The entry of this vein is at the inferior posterior aspect usually about 2 cm from the point where the portal vein arises from the superior mesenteric and splenic veins. The posterior arcade also empties into the first jejunal vein via the posterior inferior pancreatico-duodenal vein

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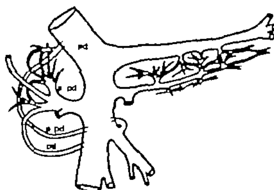


Fig 1 Venous anatomy of the pancreas derived from dissection PSPD = posterior superior pancreatico-duodenal vein ASPD = anterior superior pancreatico-duodenal vein GCT = gastro-colic trunc PIPD = posterior inferior pancreatico-duodenal vein AIPD = anterior inferior pancreatico-duodenal vein TP = transverse pancreatic vein

The anterior arcade is formed by the anterior superior pancreatico-duodenal vein and the anterior inferior pancreatico-duodenal vein The former empties into the superior mesenteric vein at its right lateral aspect after having joined the right gastro-epiploic and right colic veins to form the gastro-colic trunc The anterior inferior pancreatico duodenal vein empties into the first jejunal vein often after having formed a common inferior pancreatico-duodenal vein together with the posterior inferior pancreatico-duodenal vein (DESCOMPS & LALAUBIE 1912 PETREN 1929 DOUGLASS et coll 1950 FALCONER & GRIFFITHS 1949)

The body and tail of the pancreas are drained by the transverse (inferior) pancreatic vein passing at the inferior posterior surface of the pancreas It either empties directly into the superior or inferior mesenteric vein at their left lateral aspect Several small veins with individual entry into the splenic vein also collect the blood from the body and tail of the pancreas (DOUGLASS et coll FALCONER & GRIFFITHS)

Material and Methods The pancreatic veins were selectively catheterized in 40 patients 33 of whom with a malignant tumour outside the pancreatico-duodenal area for example the colon They were referred for portography to demonstrate possible liver metastases the transumbilical technique was used These patients constitute the control series

The remaining 7 patients were examined with the transhepatic catheterization technique The patients had jaundice and were referred for percutaneous transhepatic cholangiography Four of these patients had carcinoma of the bile ducts without involvement of the pancreas at operation two patients had carcinoma of the pancreas subsequently verified at surgery and one patient with portal hypertension was examined during portography



Fig 2 Normal phlebographic anatomy of the pancreas ( ) p and b) right posterior oblique view. Catheter in posterior sup rior pancre tico-duodenal vein. Filling of posterior and terior arcus readies emptying in inferior pancreatico-duodenal vein and ga tro-colic trunc

Technique

The selective catheterization of the pancreatic veins was p rformed via two different routes

Transumbilical approach The remnant of an umbilical vein is op-ratively dilated by a probe and a soft catheter introduced into a branch of the left portal vein The patient is then brought to the department of diagnostic radiology During fluoroscopy a guide wire is introduced into the main branch of the left portal vein The guide wire has a sharp bend at the tip and can therefore be manipulated down into the main stem of the portal vein The op-ratively introduced catheter may then be changed to a thin walled catheter (OD/ID 2 2/1 4 mm) without sideholes This catheter is preformed with a slight bend of the first 5 cm of the tip Th bend at the tip of the catheter may allow it to be passed along the inferior wall of the portal vein and the pancreatic veins can be catheterized An introduction of the bent guide wire into the pancreatic vein may facilitate the insertion of the catheter in some cases

Transhepatic approach The catheter i inserted by the usual techniqu for transhepatic cholangiography If the tip of the catheter fails to lie in a branch of the portal vein the catheter is lowly retracted until blood starts to drop and

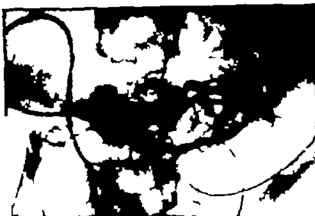


Fig 3 Normal phlebography of the tail of the pancreas Ca he er in branch f splenic ein Transverse pancreatic ein filled through abundan anastomo es in parenchyma

a few ml of contrast medium are injected for identification of the portal vein A guide wire is then introduced and manipulated into the main stem of the portal vein If only a thin branch has been punctured this manipulation may be extremely difficult A bend on the tip of the guide wire or a J formed guide wire may be of help Extreme care must be taken not to injure the liver parenchyma or displace the tip of the catheter After the guide wire has been passed down into the portal vein the catheterization of the pancreatic veins is performed in the same way as with the transumbilical technique

After entering a pancreatic vein 10 ml of Isopaque Coronar Nyegaard are injected by hand taking care that the catheter is not wedged in the mall veins Two films per second are exposed during 5 seconds in a p and right posterior obl qu projections The catheter is then withdrawn to the portal vein and 40 ml of the contrast medium injected to demonstrate possible involvement of portal or sup rior mesenteric veins or liver metastases

Results

The posterior superior pancreatico-duodenal vein was catheterized in 33 pa tients the anterior superior pancreatico-duodenal vein in two and veins from the body and tail of the pancreas in four patients In one additional patient filling of venous arcades was obtained by injection of contrast medium into the ga tro-colic trunk The normal anatomy of the pancreatic veins at phlebography is illustrated in Figs 2 and 3 The veins had a different appearance in two pa tients with pancreatic carcinoma. In one patient several venous branches were obstructed and others appeared irregularly invaded by a neoplasm which was small and resectable (Fig 4) The other patient had an inextirpable tumour



Fig 4 Phlebography in carcinoma of the head of the pancreas Catheter in posterio superior pancreatico-duodenal ei I f ltration nd occlusion of branches (→) Draining catheter ho in common bile duct

which invaded the portal vein Catheterization of the posterior superior pan creatico-duodenal vein was possible but the vein was compressed by the tumour and filling of other veins in the region of the head of the pancreas was not obtained

Complications Pancreatic phlebography with the transumbilical technique was performed without other complications than small extravasations which occurred in two patients In one of these injection of the contrast medium was performed with the catheter in wedged position The extravasation encountered required no treatment Two of the seven transhepatically catheterized patients required emergency operation because of intraabdominal bleeding

Discussion

The catheterization of pancreatic veins is more easily performed by the trans-hepatic than by the transumbilical approach The reason is that with the former technique the catheterization i made in the direction of the catheter while the latter will require the catheter to be passed round the sharp bend formed by the left branch and the main stem of the portal vein With some experience catheterization seems to be pos ible in most patients The posterior superior pancreatico-duodenal vein i most easy to enter Sometimes however this vein joins the portal vein at an acute angle and then it may be difficult to obtain a table position of the catheter A bend of the tip of the guide wire may facilitate the in troduction of the tip of the catheter deeper into the vein in such cases

Since there are abundant anastomoses between the posterior and anterior arcades most of the veins in the head of the pancreas including the inferior pancreatico-duodenal vein are demonstrated by injection into the posterior superior pancreatico-duodenal vein In some cases however only filling of the veins of the posterior part of the head is obtained In such cases and in cases where catheterization of the posterior superior *pancreatico-duodenal vein is impossible* the anterior superior pancreatico-duodenal vein should be examined as well Catheterization and injection of contrast medium into the gastro-colic trunk however generally demonstrate only gastric and colonic veins and only seldom permit filling of the pancreatic veins The catheter therefore must be placed selectively in the anterior superior pancreatico-duodenal vein Again bending of the tip of the guide wire generally makes it possible to enter also this vein

In our experience the catheterization of the veins from the body and tail of the pancreas entails more difficulties because the veins are small and the anatomy variable This however is probably just a matter of experience

The transjugular approach for catheterization of the portal vein HANAFEE & WEINER 1967) could possibly be used also for selective catheterization of the pancreatic veins and may be as convenient as the transhepatic one but has not been tried by us

The venous anatomy as revealed by dissection seems to be valid in most cases In the head of the pancreas however many variations occur and in this material two posterior superior pancreatico-duodenal veins were more common than might be expected from the literature An account of the venous anatomy will be given in more detail when more experience has been gained

The fact that two patients had to be explored surgically because of intra abdominal bleeding may make the transhepatic approach appear riskful These complications happened early in the series and at that time a red thin walled catheter was introduced into the liver At present a much thinner catheter is used and evident intraabdominal bleeding has not occurred The risk of complications of this type may be less with the transjugular technique Another point worth stressing is that the transhepatic technique was used only in patients with jaundice in whom there is increased risk of bleeding Drainage of the biliary tract by a percutaneously inserted catheter for some days and pancreatic phlebography in a second session are probably to be preferred It should not be forgotten al o to p rform an injection into the main stem of the portal vein as this is of great importance in the evaluation of operability of tumours in this region

The value of pancreatic phlebography in the diagnosis of lesions in the pancreatico-duodenal region is at present too early to estimate Theoretically the method should be useful in the diagnosis of carcinoma of the pancreas since this tumour is apt to invade the veins early while the arterial encasement appears

later Pancreatic phlebography in the differentiation between inflammatory and malignant lesions should also be investigated

Catheterization of pancreatic veins must definitely be of value in the investigation of patients with islet-cell tumours, in whom blood samples may be collected for analysis of insulin and gastrin

SUMMARY

A method for selective pancreatic phlebography using the transumbilical or transhepatic approach is described The results from a material of 40 cases 2 of whom with carcinoma of the pancreas are presented

ZUSAMMENFASSUNG

Eine Methode zur selektiven transumbilikalen oder transhepatischen Phlebographie des Pankreas wird vorgelegt Die Ergebnisse in einem Material von 40 Patienten von welchen 2 Karzinom des Pankreas hatten werden vorgelegt

RÉSUMÉ

Présentation d une méthode de phlébographie sélective du pancreas par voie transombilical ou transhépatique Les résultats acquis sur un matériel de 40 malades dont 2 avaient un cancer du pancréas sont donnés

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ORBITAL PHLEBOGRAPHY

II. Anatomy of superior ophthalmic vein and its tributaries

JAN BRISMAR

At orbital phlebography the diagnosis has been based largely upon changes in the appearance of the superior ophthalmic vein, except for those comparatively rare cases where tumor veins or venous malformations are demonstrated. It is then surprising that little information is to be gained from the literature concerning the normal variations in the course of the vein, if the course is similar in both orbits, the normal width of the vein and if this be related to technical factors at the examination. The reports available are partly contradictory, and it is also uncertain what diagnostic value is attached to an incomplete demonstration of the vein. As orbital phlebography is gaining increasing interest the present investigation was undertaken to acquire a deeper knowledge of the anatomy of the superior ophthalmic vein and its variations as a basis for the differentiation between normal and pathologic conditions.

Anatomy

Dissections of the orbital veins were performed by SESEMANN (1869) and GURWITSCH (1883). The superior ophthalmic vein is the main intraorbital vein

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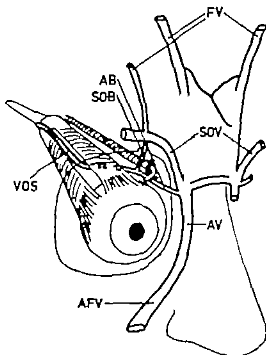


Fig. 1. Superior ophthalmic vein (VOS) and the facial veins near the orbit. Frontal veins (FV). Supraorbital veins (SOV). Angular vein (AV). Anterior facial vein (AFV). Angular (AB) and supraorbital (SOB) tributary branches to superior ophthalmic vein.

and is connected by abundant collaterals directly or indirectly with all other intraorbital veins (GURWITSCH). It is formed closely behind the pulley of the superior oblique muscle by the junction of two branches, one from the supraorbital vein passing through the supraorbital incisure and above the pulley, the other from the angular vein passing along the medial orbital wall and below the pulley (SESEMAN). *The latter author stated that both branches were wide* but that the supraorbital branch often was the larger one.

The most anterior part of the superior ophthalmic vein lies close to the orbital roof (ARON ROSA et coll. 1967). The vein then turns laterally, enters the muscular cone and passes backwards laterally under the superior rectus muscle. It crosses the muscular cone to appear on the lateral side of the superior rectus muscle and continues lateral to the musculus levator palpebrae above the lateral rectus muscle. Approaching the superior orbital fissure, the vein turns downwards to pass through the fissure to enter the anterior part of the cavernous sinus (*Fig. 1*). *SESEMAN as well as GURWITSCH mention that the superior* ophthalmic vein often is divided into two or even three branches that later join again.

Contrary to the general opinion of that time SESEMAN stated that the width of the vein increased successively as the vein passed backwards through the orbit

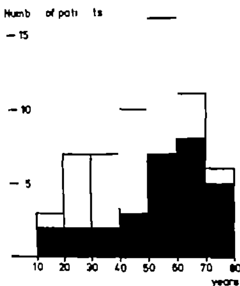


Fig Age and sex distribution of the material □ males ■ females

and then considerably decreased as the vein passed through the orbital fissure Previously a widening of the vein close to the cavernous sinus—a sinus ophthalmicus—had been described MERKEL (1874) was not able to confirm the opinion of SESEMAN Like previous authors, he found a constant widening of the posterior part of the vein GURWITSCH stated that following a constant narrowing during the passage through the superior orbital fissure a widening of the lumen as the vein approached the cavernous sinus often occurred thus explaining the earlier differences in opinion

Methods

The technique used for orbital phlebography is previously described in detail (BRISMAR) Only a brief summary will be given here A teflon cannula is percutaneously inserted into a frontal vein During compression of the frontal and the angular veins serial films are exposed in five different projections an a p view (angulated 10 from below) one straight lateral and one oblique lateral view and an axial view One series of films is also exposed in an a p view before applying compression For each series 10 ml of contrast medium (Isopaque cerebral Nyegaard) is injected in approximately 1 s Photographic subtraction is routinely used All measurements have been made directly on the films using a scale lupe (7X) The focus-film distance has been 100 cm for the a p views and 90 cm for the lateral view The patient's head has always been in direct

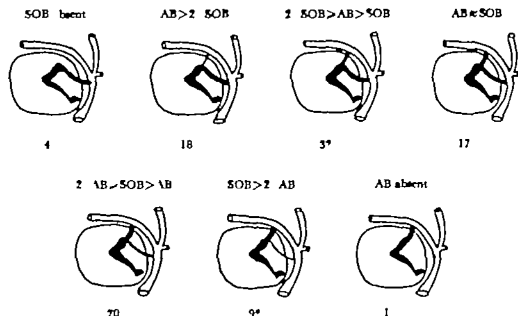


Fig 3 The diameter of the angular branch (AB) in relation to the diameter of the supraorbital branch (SOB) of the tributaries to the superior ophthalmic vein

contact with the automatic cut film changer (AOT or PUCK, Siemens Elema) No correction for magnification factors has been made

Material

The material (Fig 2) consists of the first 60 patients from the series previously presented (BRISMAR) All patients were referred for possible disorders either intraorbitally or affecting the cavernous sinuses or the adjacent basal venous sinuses of the skull In nine patient however the final clinical evaluation did not support the presumption of such a disorder

In order to obtain a normal material the total number of 120 orbits of the material had to be reduced by orbits not adequately examined and by those with a clinically possible intraorbital disorder

Sixty two orbits remained as the normal material and were referred to two groups as follows

Group N 42 orbits (both orbits in seven patients) with no clinical signs of disorder affecting the orbit or the cavernous sinus.





b

Fig 4 Different types of origin of the superior ophthalmic vein a) The supraorbital tributaries (→) are wide the angular tributaries (⟼) narrow Asymmetry of the anterior parts as well as unilateral right sided duplication of the middle part of the superior ophthalmic vein b) Dominant angular tributaries (⟼) On the left side small supraorbital branch (→) but no supraorbital branch on the right side

Group S 20 orbits in 10 patients with an intrasellar expanding lesion causing compression but not occlusion of the cavernous sinuses As it could not be excluded that the drainage of the orbital veins through the cavernous sinus was impaired (though a good passage of contrast medium through the cavernous sinus occurred at the phlebography) the groups N and S were evaluated separately for analysis of the width of the superior ophthalmic vein

Results

Topographic information on the facial veins around the orbits including the tributaries to the superior ophthalmic vein is valuable for the puncture and may be indispensable for the application of digital compression in order to direct the flow of medium into the orbits

Facial veins These veins were adequately filled with contrast medium in 51 patients allowing an analysis of the venous anatomy in the vicinity of the orbits

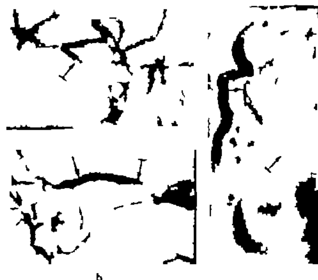


Fig. [illegible] Phlebographic appearance of the superior ophthalmic vein and its three segments in ( ) [illegible] view, (b) lateral view and ( ) [illegible] view. Anterior segment anterior to arrow (→) indicating lateral deflection point. Middle segment between arrows. Posterior segment posterior to arrow (→).

Two or more frontal veins was the most common finding; a single vein occurred in only 13 cases. The diameter of the widest frontal vein exceeded 2 mm in all but four cases. Generally (30 patients) a frontal vein on each side continued down to the medial canthus where it joined the ipsilateral supraorbital vein to form the angular vein, which continued downwards as the anterior facial vein. The supraorbital vein originates lateral to the orbit, where it anastomoses with the extracranial temporal veins and passes medially along the superior orbital ridge between the frontal muscle and the musculus corrugator supercilii. It then perforates the orbicular muscle to reach the frontal vein at the medial canthus of the eye. In 105 orbits the supraorbital veins could be observed. In two cases no supraorbital vein could be demonstrated on one side, in spite of an adequate filling of the veins in the vicinity. In 30 orbits the vein was filled only from the medial canthus to the supraorbital incisure—probably a valve existed lateral to this incisure in these cases. In 40 orbits a frontal vein anastomosed with the supraorbital vein near the supraorbital incisure. In the vast majority of cases wide collateral veins connect the two halves of the face in the forehead as well as at the root of the nose. However, in a few cases these communications were so narrow that the passage of contrast medium to the contralateral orbit was impaired.

Superior ophthalmic vein. The origin of the superior ophthalmic vein could be evaluated in 107 orbits. The minimum diameters of the supraorbital and the angular tributaries were measured in the view where they were best demon-

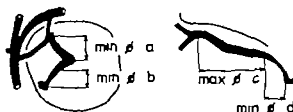


b

Fig 6 Bilateral duplication of the superior ophthalmic vein On the left side only the middle part of the vein is double while on the right side the double segments include the anterior as well as the middle part of the vein Bilateral filling of inferior ophthalmic vein a) A p projection b) Semi axial projection

strated and the cases then classified (Fig 3) In half of the cases the angular tributary was the widest and in one third the supraorbital tributary was wider (Fig 4) The course of the superior ophthalmic vein in this material corresponded to previous reports on orbital anatomy and phlebography (Fig 5 Eventually the same nomenclature as that of HANAFEE et coll (1968) is used by the present author (Fig 5) The anterior segment of the superior ophthalmic vein crosses under the superior rectus muscle and runs a course directed laterally backwards The middle segment commences at the lateral inflexion point where the vein reaches the lateral border of the superior rectus muscle and then follows the lateral border of that muscle dorsally medially towards the superior orbital fissure The posterior segment is best observed on a lateral view It begins where the vein turns downwards to pass through the superior orbital fissure and ends where the vein enters the cavernous sinus

In one third of the orbits at least a part of the vein was duplicated and in a few cases the veins were paired in their entire course through the orbit Fig 6)



Measurements during compression

	N (= 36)	S (n = 17)	N+S (n = 53)
	3 0	2 7	2 9
	(1 1 – 6 0)	(1 3 – 5 5)	(1 1 – 6 0)
b	1 2	1 3	1 2
	(0 5 – 2 0)	(0 7 – 1 9)	(0 5 – 2 0)
	3 6	3 4	3 5
	(1 9 – 5 6)	(1 8 – 5 8)	(1 8 – 5 9)
d	1 8	1 7	1 8
	(1 2 – 2 4)	(1 3 – 2 3)	(1 2 – 2 4)

Fig 7 Different diameters of the superior ophthalmic vein during compression I the a p view the minimum diameter was measured in the superior rectus curve ( ) as well as in the posterior segment (b) In the lateral view the maximum diameter of the intraorbital part of the vein ( ) as well as the minimum diameter the posterior segment (d) was measured Mean values and ranges displayed for the groups N (normal orbit and cavernous sinuses) and S (normal orbit intrasellar expanding lesion) separately as well for the total series (N + S)

In cases with incomplete duplication this usually occurred around the lateral deflection point (Fig 15) The duplications were short in almost half of the cases

Diameters The diameter of the superior ophthalmic vein was constantly reduced as the vein passed through the supraorbital fissure also in this material The diameter of the vein was measured directly on the films exposed during compression (Fig 7) Mean values were calculated separately for the groups N and S (the number of orbits allowing measurement reduced to 36 and 17 respectively as some veins were not suited for measurement mostly because of vein duplication) No differences between the two groups were found Mean values and ranges for the groups N and S are given separately as well as sum



Fig 8 Marked local widening of the internal part of th superior ophthalmic vein sinus ophthalmicus (→) a) A p b) lateral view

marized (Fig 7) The superior ophthalmic vein after having passed through the superior orbital fissure, in most cases increased in width while descending to the cavernous sinus A significant widening of the internal part of the vein was present in several cases (Fig 8) probably corresponding to the sinus ophthalmicus described by 19th century anatomists

Significance of non filling of the superior ophthalmic vein Without compression the superior ophthalmic vein was demonstrated in 79 out of the 104 orbits adequately examined Ten out of the remaining 25 in which the vein did not fill with contrast medium proved to have an intraorbital lesion

During compression non filling of the vein occurred in only one orbit in a patient with a large sphenoidal ridge meningeoma with marked protrusion of the orbital contents In all other cases adequately examined the superior ophthalmic vein was demonstrated in its entire course or close to the site of an occlusion Even in a case with a large fistula between the carotid artery and the cavernous sinus the vein on the side of the fistula could be filled (Fig 9) This indicates the efficacy of the technique used and stresses the importance of adequate compression and rapid injection of medium

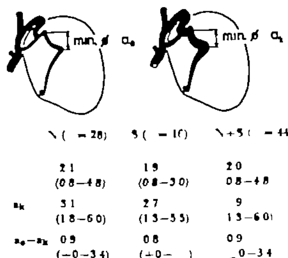
The effect of compression on the width of the vein was evaluated separately for the groups N and S (the number of cases reduced to 28 and 16 respectively after exclusion of orbits not examined without compression or where the vein was not filled without compression or was duplicated) No differences could be found between these two groups Mean values and ranges are given in Fig 10 for the groups separately as well as for the total series of 44 orbits The mean increase in diameter during compression was about 45 per cent with a range



Fig.) Arterio enc f tula supplied f om bran hes f he external rotid rtery b. Orbital phleb graphy. A f r m u t f filling of the in rl tal eins

from 0 up to 200 per cent (Fig. 11). The widening may even cause an evid nt displa ement of the vein (Fig. 12).

Differences between left and right orbits in the course of the superior ophthalmic vein were assessed in 17 subjects. Seven of the e had normal cavernous sinuses and 10 had an intrasellar expanding lesion without signs of obstruction of the flow. In six patients no significant difference existed between the left and the right orbit. Asymmetric duplications of the superior ophthalmic vein without any significant asymmetry in the course of the vein was observed in six ca es. In four of these the double segments were unilateral, three of them very short; in two cases different types of duplications of the right and left superior ophthalmic vein were encountered. Significant asymmetry between the two orbits existed in five patient. In one of these it cannot be excluded that an asymmetric injection of contrast medium may have contributed to this difference. In the remaining four patients (two from each of the group N and S) the superior ophthalmic vein was more or less duplicated in two (Fig. 13) only a very short double segment existed at the lateral deflection point. In several cases the anterior part of the superior ophthalmic vein on one side described an extra loop in the a.p. view (Fig. 1 a); only one of these wa also included in the group of 17 cases used for evaluation of the intraindividual differences.



	N (= 28)	S (= 16)	N + S (= 44
	2 1 (0 8—4 8)	1 9 (0 8—3 0)	2 0 0 8—4 8
a_k	3 1 (1 8—6 0)	2 7 (1 3—5 5)	9 1 3—6 0)
$a_0 - a_k$	0 9 (±0—3 4)	0 8 (±0—)	0 9 _0—3 4

Fig 10 Effect of compression Only series with filling of the superior ophthalmic vein already without compression are included The minimum diameter of superior ophthalmic vein in superior rectus curve as measured on the p... from series exposed without ( ) as well as with (k) compression Mean values and ranges displayed for the groups N (normal orbit and cavernous sinuses) and S (normal orbit intrasellar expanding lesion separately as well as for the total series (N S)

Discussion

The technique used in this investigation (Brismar) gives more distension of the facial veins than other techniques This may explain why the constancy of the double origin of the superior ophthalmic vein described by the classic anatomists and also assessed in this series has not been observed by many previous authors at orbital phlebography Boudet (1953 1955) mentions that *in addition to a superior main branch (the supraorbital tributary) a small accessory inferior branch (the angular tributary) may exist* From his illustrations it is evident however that he sometimes confuses the two tributaries Lombardi & Passerini (1968) describe the angular branch as the proximal part of the superior ophthalmic vein However they state that the first segment was sometimes absent and its place then taken by a superficial vessel that united directly with the next segment From their illustrations it is evident that this vessel is the supraorbital branch

Several authors have regarded the angular tributary to the superior ophthalmic vein as the first part of that vein In the French literature the appearance



Fig. 11. Orbital phlebography without (a) and with compression (b).

of the superior ophthalmic vein in the a.p. view is classically described as a parallelogram with one side absent. In an a.p. view, angulated 10° from below, OFFRET & ARON ROSA (1965) measured the angles of this parallelogram. Their normal values (50° to 60° for the angle between the angular tributary and the first part of the superior ophthalmic vein and 110° for the lateral angle) were questioned by LOMBARDI & PASSERINI, however, as those angles may vary considerably with small changes in projection.

An evident displacement of the superior ophthalmic vein, such as is often observed in intraorbital tumors, causes few diagnostic problems. The frontal vein approach to orbital phlebography (VRITSIOS 1961) allowed a comparison between the veins in the right and left orbits, and even small differences in the course of the veins could be disclosed. However, in the present material quite large differences in the course of the superior ophthalmic vein normally existed between the right and left orbits. Thus, caution must be taken not to diagnose a localized expansive lesion in such cases. The interindividual differences are still larger, and thus it is not possible to give normal values for the course of the superior ophthalmic vein.

HANAFEE (1972) stresses the importance of not jumping to the conclusion of

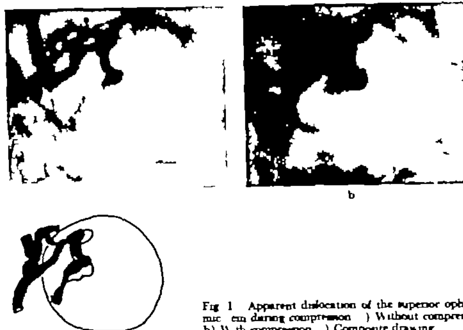


Fig 1 Apparent dislocation of the superior ophthalmic vein during compression) Without compression b) With compression) Composite drawing

superior ophthalmic vein obstruction as lack of filling of the posterior aspects of the superior ophthalmic vein may be a purely technical result or may be related to an increased flow phenomenon When passage of contrast medium to the orbit is not impaired by narrow collateral veins or by compression of these veins and when the external digital compression is effective non filling of the superior ophthalmic vein is a definite pathologic finding if the author's technique of injection is used This statement is contrary to the opinion expressed previously (HANAFEE et coll 1968) The rapid injection of contrast medium also causes a distension of the orbital veins Thus the average diameter of the superior ophthalmic vein in this material exceeds the maximal values for normal variations given by OFFRET & ARON ROSA (1965) and ARON ROSA et coll (1966) The former claimed that the diameter of the superior ophthalmic vein in normal cases did not exceed 2 mm ARON ROSA et coll increased that limit to 2 5 mm HANAFEE et coll reported diameters varying from 1 to 5 mm in normal subjects They also found that in the same individual one ophthalmic vein could be twice as wide as the other The amount of contrast medium reaching each orbit is dependent on the injection site on variations in the anatomy of the facial veins and on the efficacy of the applied external compression Thus the diagnostic significance of differences in width of the right and left superior ophthalmic veins is limited The high incidence of unilateral varicosity reported by some

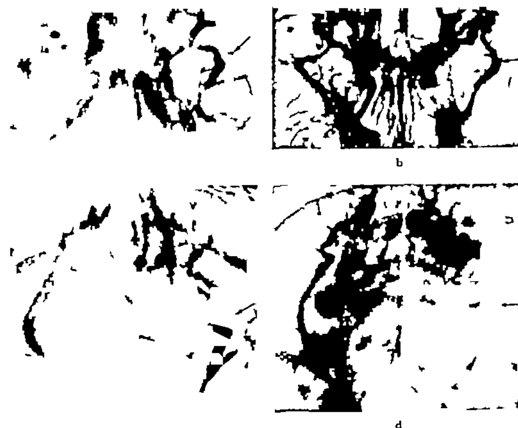


Fig. 13. Two patients with [illegible] possible retroorbital disorder demonstrating marked asymmetry of the superior ophthalmic vein [illegible] the patient [illegible] unilateral duplication of the [illegible] ophthalmic vein was found (→) [illegible] First patient [illegible] Second patient [illegible]

authors (ARON ROSA et coll. 1966) may be at least partly due to the use of too narrow limits for the normal variations in width of the vein, possibly in combination with a lateralized injection of contrast medium.

The technique used in orbital phlebography, whether performed via angular or frontal vein injection or via injection through the inferior petrosal sinuses, always induces a local increase in venous pressure which may disturb the normal flow. Manual or mechanical compression manoeuvres increase this disturbance. Thus valid conclusions concerning the dynamics of flow in the intraorbital veins can hardly be based upon orbital phlebography.

Whether the flow in the superior ophthalmic vein is directed from the facial veins to the cavernous sinus or vice versa has been discussed for a long time. SESEMAN considered that the superior ophthalmic vein acted as an emissary vein

for the cavernous sinus. He based this opinion on the observation that the superior ophthalmic vein had a much smaller diameter at the cavernous sinus than at its facial end. He considered that normally the orbit drained mainly towards the facial veins but that a smaller amount of blood also passed to the cavernous sinus. When pressure increased in the sinus blood was thought to pass from the sinus via the orbit towards the facial veins. A previous prevalent conception of a flow from the facial veins towards the cavernous sinus was based on the fact that the intraorbital veins join at an acute angle directed towards the cavernous sinus. SESEMAN stated, however, that the rich network of anastomotic veins in the orbit reduced the weight of that argument.

MERKEL (1874), not having been able to confirm a narrowing of the internal part of the superior ophthalmic vein, questioned the opinion of SESEMAN. DONDERS (1871) pleaded that the blood from the orbit normally flowed through the cavernous sinus to the internal jugular vein. As no valves exist in the veins of the orbit DONDERS suggested that the direction of flow could be reversed in cases of flow impairment. GURWITSCH demonstrated, as did SESEMAN previously, that the lumen of the superior ophthalmic vein was constantly reduced as the vein passed through the superior orbital fissure. He supposed, however, that not only the orbital blood, but also some blood from the facial veins drained through the orbit to the cavernous sinus.

HANAFEE (HANAFEE et coll. 1965, 1968, HANAFEE 1972) has successively changed opinion. In the first report (1965) on orbital phlebography it was stated that the superior ophthalmic vein drained directly into the cavernous sinus, in the following (1968) that the superior ophthalmic vein drained posteriorly into the cavernous sinus through the superior orbital fissure as well as anteriorly into the angular vein, and in a more recent report (1972) that the flow in the superior ophthalmic vein generally is in the postero-anterior direction.

Based on carotid angiography with filling of the superior ophthalmic vein most authors at present consider that the flow normally is directed towards the cavernous sinus, but that a reverse flow may occur in cases with intracranial disorders (HACKER & PORRERO 1969, TORNOW & PISCOL 1971, TORNOW 1972). Preliminary results of the present author coincide with these opinions.

SUMMARY

The anatomy of the superior ophthalmic vein and its variations in material of orbital phlebography are described. The diameter of the vein varied within a wide range in apparently normal subjects. No complete symmetry existed between the two orbits. Care must thus be taken not to overdiagnose intraorbital expansive lesions from venous asymmetries.

ZUSAMMENFASSUNG

Die Anatomie der oberen Orbitalvene und deren Variationen werden bei einem Material on Orbitalphlebographien beschrieben Der Diameter der Vene w es eine grosse Variation bre te bei ffenbar normalen Personen uf Es bestand keine llstandige Symmetrie zwischen den beiden Augenhohlen Mann muss oruchtig sein nicht intraorbitale expandierende Schaden aus Asymmetrien der Venen zu uberdiagnostizieren

RÉSUMÉ

Description d l anatomie de la eine ophtalmique superieure et d ses variations sur une serie de phlebographies orbitaires Le diametre de cette eine est tres ariable chez des sujets apparemment normaux Il n y a pas d symetrie absolue entre les deux orbites Il faut donc eiller à ne pas porter trop souvent le diagnostic d lesion expansive intraorbitaire sur la base d asymetries veineuses

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COMPUTER ASSISTED TOMOGRAPHY OF INTRACRANIAL CSF CIRCULATION USING A WATER-SOLUBLE CONTRAST MEDIUM

TORGNY GREITZ and TOMAS HINDMARSH

By the introduction of isotope cisternography (DI CHIRO 1964) a new tool was provided for the investigation of the circulation of the cerebrospinal fluid (CSF). To-day this method is regarded as indispensable in the examination of patients with disturbances of CSF dynamics, especially those with communicating hydrocephalus. However, isotope cisternography is hampered by certain drawbacks. Passage of the tracer material to the ventricular system is an important sign of pathology but may be difficult to ascertain, especially in patients with small ventricles due to the low resolution of isotope scanning methods. Furthermore, the ventricles in the lateral view are superimposed on the sylvian fissures and in the a.p. and axial views on the interhemispheric fissure, these fissures being main CSF pathways usually contain large amounts of the isotope which may render evaluation of ventricular filling difficult. Another disadvantage of the method is the relatively high radiation doses to the spinal cord (HILDITCH 1968, WAGNER et coll. 1970) which significantly restricts the number of examinations that can be made in one and the same patient. Computer assisted axial tomography (HOUNSFIELD 1973, AMBROSE 1973), in the following referred to as

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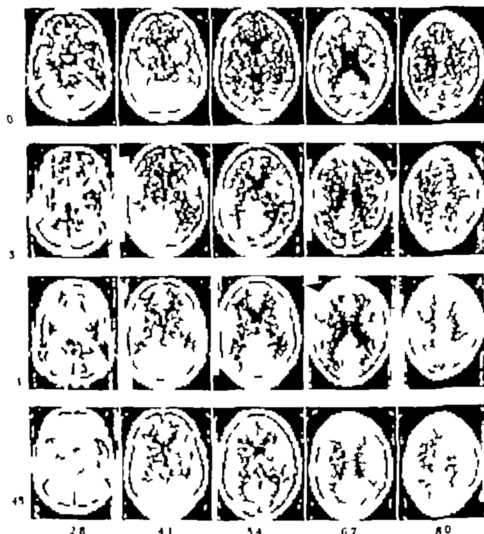


Fig. 1. Normal case. Intracranial distribution of metrizamide following myelography by the lumbar route at time intervals (h) as indicated by figures to the left. Lower figures indicate tomographic level in cm above external meatus. Sections parallel to the supraorbitomeatal line. After 3 hours contrast medium in the cisterns of the posterior fossa, in the quadrigeminal and ambient cisterns, in the suprasellar cisterns as well as in the Sylvian and interhemispheric fissures and beginning to appear in the sulci over the convexity. No medium is present in the ventricular system. After 24 hours maximum concentration over the convexity and in the interhemispheric fissure. Contrast medium still discernible parasagittally after 48 hours.

CT scanning was used by HINDMARSH et coll. (to be published) to map out the routes of transport within the intracranial subarachnoid space following myelography with the water soluble contrast medium metrizamide (Nyegaard, Oslo)



Fig 2 Same case figures to the lef indicat time intervals (h) and lower figures section levels in cm Only ttenuation coefficients abov 35 are represented in the left row (basal sec tion) and coefficients abov 23 in the right ro The time difference between learance of the suprasellar cisterns and clearance f the CSF spaces in the superior part of the ter hemispheric fissure is demonstrated

This non ionic medium is well tolerated when applied to the subarachnoid cisterns (SALVESEN 1973 GONSETTE 1973 GREPE & WIDEN 1973 GREPE 1975) The sensiti ity of computer assisted tomography in detecting differences

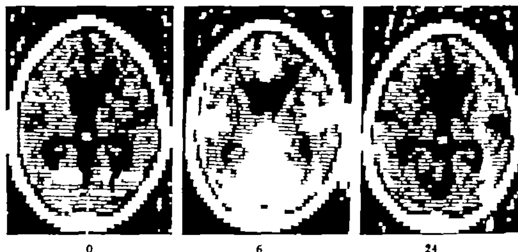


Fig 3 A slight filling of the lateral ventricles and the third ventricle in the 6 hour scan

in tissue attenuation (absorption) is about 100 times that of conventional radiography An iodine solution containing only 1—2 mg/ml has a higher attenuation than brain tissue and hence even a lower concentration has an attenuation high enough to be differentiated from normal CSF

Material and Methods Eight patients without signs or symptoms of impediment of the intracranial CSF circulation were examined with computer assisted axial tomography before and at varying intervals after myelography of the thoracic and cervical regions usually at 3 6 24 and 48 hours These patients were considered to be normal with respect to the intracranial CSF circulation although three of them had a partial block of the CSF pathways in the spinal canal In addition one examination was made in a patient who had clinical signs of communicating hydrocephalus evidenced by characteristic findings at encephalography and by an intraventricular isotope uptake at cisternography For the purpose of uniformity the contrast medium was brought up to the cervical region also in this patient The amount of metrizamide administered varied between 8 and 18 ml of a solution containing 170 200 or 300 mg I/ml corresponding to a mean dose of 2 75 g I (range 1 6 to 3 9 g I)

The tomographic sections were 1 3 cm thick and parallel to the supraorbitomeatal line All patients were scanned in the supine horizontal position but the head-end of the bed was raised about 15 to 20 between scanning procedures and for 24 hours after the injection Between 24 and 48 hours no postural restrictions were imposed upon the patient

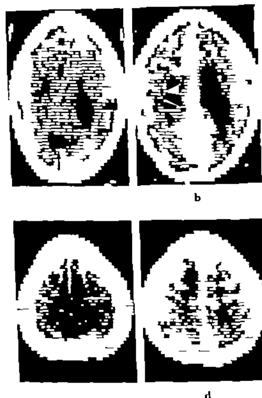
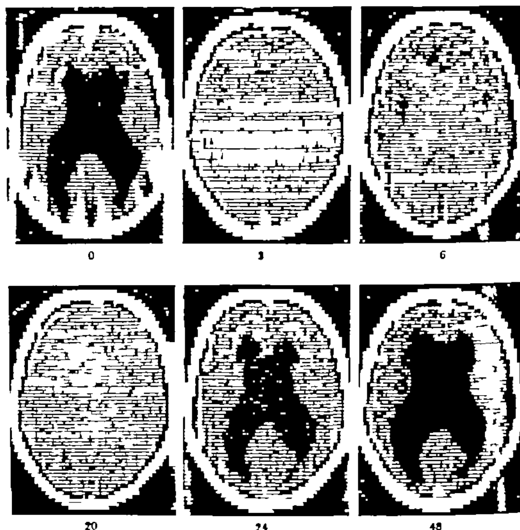


Fig 4) Patient with porencephalic cysts (→) b) These are filled with contrast medium which proves their communication with the subarachnoid space d) Normal case The sulci over the convexity not seen before injection ( ) but filled with contrast medium 24 hours after injection (d)

Results

In all patients the contrast medium filled the cisterna magna as well as the ambient and quadrigeminal cisterns In the four patients from the normal group who were examined 1 to 3 hours after myelography the medium was seen to have spread to the basal parts of the interhemispheric and sylvian fissures Filling of the ambient and quadrigeminal cisterns occurred at the same time (Fig 1) At scanning after 24 hours the contrast medium had reached the superior parts of the interhemispheric fissure and was also observed in cortical sulci over the convexity Although most of the sulci contained contrast medium the maximum concentration seemed to occur in the parietal parasagittal region corresponding to the convexity peak normally seen in isotope cisternography (Fig 2) After 48 hours contrast medium was usually still discernible para sagittally but in a lower concentration In two patients in the normal group a slight intraventricular filling was evident, in one case at the 6 hour examination and in the other at the 24 hour examination but in none after 48 hours (Fig 3)



F g 5 Communicating hydrocephalus Scans at the same level (6 7 cm) taken before as ell as 3 6 20 4 nd 48 hours after the injection Success ptake and clearance of the contrast medium within the lateral entricles A slight increase in the size of the entricles is seen fter 3 nd 6 hours (th patient complained of headache t the same occasion) I these early scans narrow zone of relativ ly low attenuation is seen adjacent to the entricles which may reflect absorption of CSF not containing contrast medium

In another patient porencephalic cysts were filled with contrast medium and hence communicating with the subarachnoid space (Fig 4a)

In the patient with communicating hydrocephalus contrast medium filled the cisterna magna but was not observed in the supratentorial subarachnoid cisterns

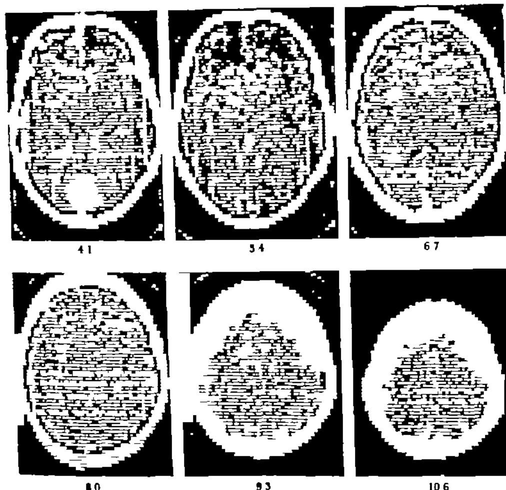


Fig 6 Same case as in Fig 5 Spatial distribution 3 hours after injection of contrast medium Marked filling of the cisterna magna and ambient cisterns slight filling of the supratentorial extracerebral subarachnoid spaces mainly of the sulci in the interhemispheric fissure and over the convexity

and sulci to any appreciable extent (Figs 5 6) Instead 1 5 hours after the injection contrast medium had passed to the ventricular system and at 3 hours after injection the attenuation coefficients of the CSF within the ventricles increased to a value higher than that of brain tissue Fig 7 demonstrates the relative variations in attenuation of the CSF within the lateral ventricles the sylvian and interhemispheric fissures as a function of time when measured in geometrically defined areas of these spaces An interesting feature was the ap

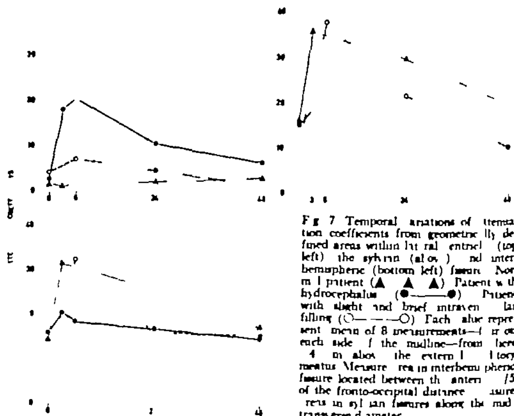


Fig 7 Temporal variations of attenuation coefficients from geometrically defined areas within lateral ventricle (top left) the sylvian (above) and interhemispheric (bottom left) fissure. Normal patient (▲ ▲ ▲) Patient with hydrocephalus (●———●) Patient with slight and brief intraventricular filling (○— — —○) Each value represent mean of 8 measurements—4 on each side of the midline—from 4 cm above the external auditory meatus. Measure area in interhemispheric fissure located between the anterior 1/5 of the fronto-occipital distance. Measure areas in sylvian fissures along the mid transverse diameter

pearance of a thin rim (estimated thickness about 5 mm) adjacent to the ventricular system with a lower attenuation coefficient than the surrounding brain tissue

Discussion

Although the image obtained by computerized tomography is built up by rather large elements each of which corresponds to a column with a height equivalent to the thickness of the examined slice i.e. 13 mm and a transverse section area of almost 3 mm×3 mm this method is still far superior to isotope scanning with regard to resolution. Contrary to the situation with isotope scanning techniques and with conventional radiography the information obtained from any given volume within the tomographic slice is not influenced by physical characteristics of tissues outside the slice. The accuracy of CT scanning allows comprehensive mapping of the pathways of tracer transport within the subarachnoid space. Even details such as filling of individual cisterns and sulci

may be discerned (Fig 4 b) This should permit a more complete and detailed analysis of the various pathways and might possibly lead to new concepts of flow patterns in the normal and pathologic CSF circulation The results obtained in normal individuals in this preliminary investigation suggest that the CSF to a larger extent than has so far been appreciated may take a posterior route over the quadrigeminal plate, in addition to the generally accepted main pathways via the sylvian and interhemispheric fissures

The rim of low attenuation seen adjacent to the ventricles in a hydrocephalic patient may reflect *a stage in the process of CSF absorption* the CSF which has a low attenuation producing this effect when absorbed from the lateral ventricles This absorption was possibly accelerated by an acute increase of hydrocephalus as evidenced from the early scans in this patient (Fig 5)

One objection to the use of a water soluble contrast medium as a tracer of CSF circulation would be its character as a non physiologic agent However this is also true of other substances used for cisternography such as RIHSA and Ytterbium DTPA Furthermore neither of these is capable of revealing all the various phases of events related to the absorption of water Metrizamide has no protein binding capacity (SALVESEN et coll 1973) Its high density may prove to be a significant drawback for tracer purposes as it leads to layer formation and makes the transport with the CSF circulation dependent partly on gravity In all patients included in this investigation the contrast medium was brought up to the cervical area by gravity under fluoroscopic control

However to evaluate the potential of water soluble contrast media as indicators of CSF flow for use routinely in cisternography by lumbar puncture the possible influence of physical factors on the spread and transport of the medium in the subarachnoid space must be established

The attenuation coefficients (as read on the computer print-outs) in regions of the subarachnoid space containing contrast medium in most of the cases corresponded to an iodine concentration of 1—2 mg/ml The density of a pure metrizamide solution of this concentration would be less than 1 005 g/ml i e lower than that of the normal CSF which varies between 1 005 and 1 009 g/ml (SUNDERMAN & BOERNER 1950) Hence it should be possible to use a comparatively large volume of a metrizamide solution with a *density close to that of* the CSF in order to ensure a rapid and reliable transport of the medium to the intracranial subarachnoid space The time table and the pathways of intracranial transport of the medium may then be evaluated taking the level of the cervicocranial junction as a starting point Work along this line is being pursued at present

By the introduction of computerized tomography it seems as though water soluble contrast media long used as indicators in the investigation of hemo-

dynamics deserve to be considered also for the purpose of investigating the CSF circulation

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SUMMARY

A method is proposed to examine the intracranial CSF circulation by computer assisted axial tomography using a low concentration of a water soluble contrast medium. Preliminary results are reported in patients with and without disturbances of the CSF circulation

ZUSAMMENFASSUNG

Es wird eine Methode vorgeschlagen die intrakranIale CSF Zirkulation mittels komputerisierter Tomographie unter Anwendung eines Wasser loslichen Kontrast Mittels zu untersuchen. Es wird uber vorlaufige Ergebnisse bei Patienten mit und ohne Storungen der CSF Zirkulation berichtet

RÉSUMÉ

Les auteurs proposent une methode d examen de la circulation du liquide cerebrospinal par tomographie traitee par ordinateur en utilisant une faible concentration de moyen de contraste hydrosoluble. Ils presentent les resultats preliminaires obtenus sur des patients avec et sans perturbation de la circulation du liquide cerebrospinal

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EXTERNAL FACTORS AFFECTING PARASTERNAL SCINTIGRAPHY WITH TECHNETIUM 99m SULFIDE COLLOID

An investigation in the rabbit

L R GORANSON and K JONSSON

The parasternal lymph nodes are of considerable clinical importance forming as they do one of the primary areas for lymph drainage from the breast (ROUVIERE 1932) they are perhaps best examined by parasternal scintigraphy usually with Au colloid injected on each side of the xiphoid process or behind it in the midline (DIETHELM et coll 1967 ROSSI & FERRI 1966 SCHENK 1966 SCHENK et coll 1966 ROSSI et coll 1968 MICHAILOV et coll 1968 KAZEM et coll 1968 1969 SEIFERT & BETZNER 1970 MEYER BURG & WILHELMI 1971 GROS et coll 1969 1972)

A similar technique with $^{99}Tc^{m}$-sulfide colloid has already been described (GORANSON & JONSSON 1974) The purpose of the present investigation was to determine whether certain external factors influence parasternal scintigraphy i e (1) the colloid itself blocking the parasternal lymphatics for consecutive examinations (2) incision and inflammatory reaction of the chest wall influ

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Table

Procedures on the examinations

Procedures	No. of animals	Remarks	
Repeat examinations after 6 days	8		
8 days	1		
14 days or over	6		
Total	15		
		Postop infection	No postop infection
Incision of the chest wall			
sterile procedure	3	2	1
non sterile procedure	9	7	2
Total	12	9	3
		Scintigraphy after 3 hours	Scintigraphy after 4 hours
Injection of contrast media into the peritoneal cavity			
Iodized oil emulsion	7	7	
Thorotrast	4	1	3
Injection of blood into the peritoneal cavity			
Heparinized blood	4	Scintigraphy 4 hours after inj	
Non heparinized blood	5	Scintigraphy 4 hours after inj	

encing or blocking the uptake of the tracer substance and (3) the injection of contrast media or blood into the peritoneal cavity with subsequent filling of the parasternal lymph vessels (COURTICE et coll 1953 HAHN et coll 1944) causing blocking of the uptake of the tracer

Material and Methods Rabbits weighing between 1.5 and 3 kg were anaesthetised with intravenous pentobarbitone sodium The Tc^{99m} S colloid for the experiments was prepared by the method of PERSSON & NAVERSTEN (1970) and was concentrated to a volume of one ml with an activity of 500 µCi Two hundred IU hyaluronidase were dissolved in the colloid half of the solution being injected sub or intracutaneously on each side of the xiphoid process The animals were placed supine under a pin hole collimator of a gamma camera (Nuclear Chicago Pho Gamma III) and the uptake in the parasternal lymphatics was followed for 15 to 60 minutes

The different procedures are illustrated in the Table The examination was

repeated at 6 days in 8 animals and at 8 days in one animal, at 34 days in 4 animals and at 48 and 71 days respectively in two animals.

The left chest wall was shaved and an incision made following the subcutaneous injection of mepivacaine (Carbocain 1 %) in 12 animals. A 3 cm incision was made in close relation to one of the nipples, the subcutaneous tissue was excised and the wound sutured; the incision was made in 9 animals under non-sterile and in 3 animals under fully sterile conditions. Scintigraphy was performed one week after the operation. Two ml of an iodized oil emulsion were injected into the peritoneal cavity in 7 rabbits immediately below the ventral portion of the diaphragm and 2 ml Thorotrast were injected in 4 rabbits at the same site. Lateral and oblique films of the chest were obtained 3 hours after injection except in 3 of those injected with Thorotrast when the roentgenograms were taken at 24 hours. Parasternal lymph vessels and lymph nodes in the superior mediastinum were demonstrated in all the animals. Scintigraphy was performed shortly after radiography.

Twenty ml of unprepared rabbit blood were injected intraperitoneally in 5 animals and 20 ml of heparinized rabbit blood similarly in 4 animals. The injection of a small amount of (water soluble) Isopaque under fluoroscopic control ensured that the tip of the needle for injecting the blood lay in the free peritoneal cavity. Scintigraphy was performed at four hours in the animals injected with non-heparinized blood and at 24 hours in those injected with heparinized blood. Parasternal lymph vessels and lymph nodes of the superior mediastinum from animals injected with Thorotrast and heparinized blood were dissected and examined histologically.

Results

An uptake of the tracer was noted in the bilateral groups of lymph nodes in the superior mediastinum in all healthy animals in accordance with previous findings (GORANSSON & JONSSON 1974).

Consecutive scintigrams did not indicate abnormalities; the second examination always proved to be as good as the first. Nine of the animals with an incision of the left chest wall developed local inflammatory reaction; the wound healed by first intention in 3 animals. The scintigrams were normal in all animals operated upon except one in which no uptake in the left lymph nodes was evident. In 4 of the operated animals the left lymph nodes had a greater uptake of colloid than was usual, indicating an increase in their size.

All the animals that had been examined with the iodized oil emulsion injected into the peritoneal cavity had a normal scintigram. Two of the animals previously injected with Thorotrast, had normal scintigrams. One of these had been

injected three hours before the scintigraphy No uptake in the mediastinal lymph nodes was noted in one of the animals and uptake in the right axillary lymph nodes was observed in another although not in the mediastinal nodes No uptake of the colloid was observed in one of the animals injected with heparinized blood in the peritoneal cavity The remaining animals had normal scintigrams including all those injected with non heparinized blood The histologic examination of the ventral mediastinal lymph nodes revealed blood and contrast medium in the lymph nodes and vessels proving absorption from the peritoneal cavity The subsequent histologic examination after Thorotrast revealed inflammatory reaction and oedema in the lymph nodes these as well as the parasternal lymph vessels contained much contrast medium

Discussion

The normal variations and the way in which external factors affect the examination must always be known One of the fundamental demands is that consecutive examinations must be independent of each other It has been claimed that parasternal scintigraphy with ^{198}Au colloid may easily be repeated (KAZEM et coll 1969 MICHAILOV et coll 1968 MEYER BURO & WILHELMI 1971) The present investigation permitted the same conclusion with ^{99}Tc^{m} S colloid The period of time between the first and the second examinations was chosen at random but for clinical purposes no indication for performing the second examination under 6 days after the first was apparent

Lymph from the upper part of the abdomen and the chest wall, including the breast is drained to the parasternal lymphatics (ROUVIERE 1932) Mastectomy induces inflammatory reaction and waste products have to be transported from the wound to the parasternal lymph vessels It has been claimed (ROSLER 1971) that mastectomy may block the parasternal lymph vessels making postoperative parasternal scintigraphy on the operated side less reliable It is thus impossible to say whether the lack of filling of the parasternal lymph nodes on the operated side is due to metastases or to the operation Mastectomy including axillary exploration produces gross trauma this is difficult to simulate in experimental animals No effort to do so was made in the present series but incision and removal of subcutaneous tissue ought to simulate biopsy of the breast Extensive infection developed in most of the animals No blocking of the parasternal lymph flow was noted at scintigraphy except in one animal it was not clear however whether this absence of uptake was due to inflammation or if technical factors were involved This phenomenon appeared however in only one of the 12 animals This indicates that a minor incision for instance for biopsy of a tumour of the breast does not influence parasternal scintigraphy as it is always

made under sterile conditions that cause no such extensive reaction as that observed. In 4 of the 12 animals the left mediastinal lymph nodes had a greater uptake of the colloid than was usual; this may indicate secondary hypertrophy of the lymph nodes due to the inflammation of the chest wall.

Previous investigations have always indicated that the lymphatic absorption from the peritoneal cavity is maintained through lymphatics in the diaphragm to the parasternal lymph vessels (GORANSON et coll. 1973, JONSSON & OLIN 1974). These vessels, which drain to upper mediastinal lymph nodes, have been roentgenologically demonstrated with Thorotrast (GORANSON et coll.) and iodized oil emulsions (JONSSON & OLIN) injected into the peritoneal cavity in rabbits; the emulsion is rapidly absorbed, filling the parasternal lymph vessels within five minutes. No blocking effect of the contrast medium could be demonstrated at scintigraphy three hours after the injection. The investigation has proved that a fine particle oil emulsion is well suited for a combined roentgenologic and scintigraphic examination of the parasternal lymphatics. The absorption was slow with Thorotrast. The mediastinal lymph nodes were first outlined and later the parasternal lymph vessels were filled in a retrograde direction. This indicated that the medium blocked the sinusoids of the lymph nodes and as the absorption continued filling of the lymph vessels was an obstruction phenomenon. The films should be obtained about 24 hours after the injection to obtain high quality representation of the parasternal lymph vessels with Thorotrast. This blocking effect of this medium may be the reason why the mediastinal lymph nodes were not evident in the scintigraphy of two animals; one of these animals had a collateral circulation to axillary lymph nodes, which has not been observed in previous examinations of rabbits (GORANSON & JONSSON).

Blocking of the parasternal lymphatics might be accomplished with blood in the peritoneal cavity. It may be assumed that larger particles cause blocking more readily than small ones; the iodized oil emulsion had a particle size of about 1 μm (JONSSON & OLIN) while blood corpuscles are around 7 μm. The Thorotrast particles however are about 0.20 μm in size (KABISCH 1967) but the oedema of the lymph nodes produced may explain the blocking phenomenon in those cases.

The clinical conclusion to be drawn from the present investigation is that consecutive examinations of the parasternal lymphatics with ^{99m}Tc-S colloid are possible and do not influence each other. Removal of a specimen from the breast for biopsy performed under fully sterile conditions fails to influence parasternal scintigraphy, while more extensive trauma or inflammation may block the parasternal lymph flow on the ipsilateral side. Particles in the peritoneal cavity may obstruct the lymph flow, making the parasternal scintigraphy less reliable, for instance after bleeding in the peritoneal cavity during an operation. Tumour

cells in the peritoneal cavity or peritonitis may also influence the parasternal lymph flow

Acknowledgement

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SUMMARY

The influence of external factors on 99Tcm S colloid parasternal scintigraphy in rabbits has been investigated Consecutiv examinations with technetium colloid and incision and biopsy of subcutaneous tissue f the chest wall as well as injection of ontrast media and blood into the pe itoneal cav ty are described and discussed

ZUSAMMENFASSUNG

Der Einfluss unserer Faktoren auf die parasternale 99Tcm S Kolloid Szintigraphie wurd an Kaninchen untersucht Aufeinanderfolgende Untersuchungen mit Teknetium Kollo d und Inzision und Biopsie des subkutanen Gewebes der Thoraxwand sow ie Injektion on Kon trastmittel und Blut in den Peritonealraum werden beschrieben und diskutiert

RÉSUMÉ

Les auteurs ont etudie l influence de facteurs externes sur la scintigraphie parasternal avec un colloide 99Tcm S sur d lapins Ils decrivent et etudient les examens consecutifs par le colloid au technetium et l incision et la biopsie du tissue sous cutane de la paroi thoraciq ainsi que l injection de moyens de contraste et de sang dans la cav t peritoneal

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ANGIOGRAPHIC ABNORMALITIES FOLLOWING PERCUTANEOUS NEEDLE BIOPSY OF THE KIDNEY

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Percutaneous needle biopsy of the kidney was introduced on a large scale by IVERSEN & BRUN (1951) and has since won an important position in renal diagnosis It is used today primarily for investigating inflammatory and degenerative renal changes as well as hypertension Extraction of a fragment of tissue with a needle, over 2 mm in diameter leaves a puncture canal that cannot close immediately because of the compact nature of renal tissue Small blood vessels and renal canals cannot escape damage and sometimes larger vessels may be involved Even the pelvis of the kidney or surrounding organs and tissues may in isolated cases be affected

MENO & ELKIN (1971) stated percutaneous needle biopsy of the kidney is essentially a controlled iatrogenic injury Traumatic renal lesions may be examined with great accuracy by nephroangiography (OLSSON & LUNDERQUIST 1963 ELKIN et coll 1966 HALPERN 1969) This method which gives both morphologic and functional information on renal changes has been used in analysing the consequences of renal biopsy Intrarenal arteriovenous fistulas are roentgenologically impressive and were the first biopsy induced changes to attract angiographic interest Close on 70 cases have been reported since the beginning of the 1960s of which LINDSTROM (1972) is responsible for more

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than a quarter, or 22 cases. Important publications on angiographic findings following biopsy in experimental animals appeared in the period 1969—1971 (SWEET et coll. 1969, MULLER et coll. 1969, DITSCHERLEIN 1969 and EKELUND 1970, 1971).

The interval between biopsy and angiography for the cases of human arteriovenous fistulas reported usually ranged from a few days to several months. The angiography finding immediately after percutaneous kidney biopsy was described by MENG & ELKIN and by LUNDSTROM in his monograph of 140 cases. A broad angiographic report on the complications of kidney biopsy could not be found in the literature when this investigation was commenced in 1970.

It was decided to perform angiography 2 to 5 days after the biopsy on the grounds that the possible primary signs would have disappeared and only more marked and therefore more important changes would be expected. This timing of the angiographies proved subsequently to fill the gap between those described by other workers and undertaken immediately after the biopsy and the usually later controls or the angiographies that had revealed arteriovenous fistulas.

Methods and Material. Fifty nephroangiographies were performed in 48 cases in a 14 month period of 1970—1972. Two cases were examined on two separate occasions. Five angiographic investigations were performed aortally, the others selectively, the latter being made in over half the cases in at least two projections. The angiographies represented only about a half the biopsies carried out during the same period. The patients were subjected to angiography if medical interest in the examination existed in connection with their condition or was not prevented by their negative attitude.

The biopsies were performed with the patient prone, usually by the same operator with a Silverman-Goldman needle. Before the puncture films were obtained of the kidney during inspiration and expiration with a measuring pin of metal positioned within the field. Poor definition was improved by the injection of urographic contrast medium. The puncture should as far as possible be directed at the lower lateral cortical area of the kidney which provides good accuracy of aim even despite any respiratory displacement of the organ. Renal tissue was always obtained in the series.

Ninety two per cent of the examinations were performed within four days of the biopsy and 52 per cent two days after biopsy, the other examinations being made within a week. Nine patients had slight discomfort and two had marked pain in the renal region after the biopsy. Ten entries appeared in the case reports on microscopic haematuria following the puncture. The commonest histologic findings consisted of different forms of glomerular nephritis, that is in 26 cases. Interstitial nephritis was encountered in 5 cases. Ten cases displayed various types of renal disease; no evidence of abnormality was revealed by biopsy in 7 cases.



Fig 1 Case 1 Selective nephroangiogram the day after biopsy) Small extravasation of contrast medium t the biopsy site Haematoma like soft tissue mass along th lateral contour of the lo er pole of the kidney (→) b) Scarring from the biopsy site to the kidney surface probably representing the needle track

Results

No changes in the angiographies were evident in 19 of the 50 examinations but intrarenal leakage of contrast medium from the biopsy site was observed on ten occasions Peripheral cortical ischaemic defects surrounding the puncture site occurred 12 times and arteriovenous fistulas developed in 9 examinations A combination of changes was frequent the cases for these statistics were classified according to the most prominent sign A combination of leakage and an ischaemic zone was for instance not uncommon Seven angiographies with abnormalities revealed a haematoma like soft tissue mass along the kidney contour around the puncture site Multiple arteries were present in 10 cases sometimes masking the region considerably

Haemorrhage has been one of the serious complications reported in the literature The principal cause of death in many of the 32 cases ending fatally in connection with biopsy was massive haemorrhage (DITSCHERLEIN) The same



Fig. [illegible] (Case 1) 7 days after second biopsy made 3 days after the first. a) Small extravasation 10 mm medially from that in Fig. 1. Triangular cortical defect resembling haematoma zone at the first puncture point. b) Oblique. Small extravasation [illegible] the needle track and [illegible] the biopsy [illegible]

author also collected 15 135 cases from the literature and calculated that the incidence of perirenal haematoma following biopsy was 0.56 per cent. Sixteen cases with a small subcapsular or perirenal haematoma were reported by ZSCHORNACK et coll. (1968) in a series of 29 cases of disease of the urinary tract operated upon within 1 to 2 weeks of the biopsy; a large haematoma was evident in 4 cases.

MENO & LEAIN established extravasation of contrast medium into the needle track in 17 out of 18 cases at angiography immediately following biopsy as well as perirenal extravasation in 6 cases. LUNDSTRÖM observed leakage of medium in 102 of his 140 cases during a similar period.

Contrast medium leakage occurred intrarenally in all the present 10 examinations. Changes were evident within the cortical region 5 to 10 mm from the renal contour. The leakage began to appear at the beginning of the arterial phase in the form of a 1 to 10 mm accumulation of contrast medium which usually persisted long into the parenchymal phase of the angiography. Two of the 10 cases had a soft tissue mass in association with the renal outline around the puncture site.



Fig 3 Case 2 Selectiv nephroangiography 2 days after biopsy Double renal arteries) Contrast medium leakage from dorsal artery b) Small extravasation from the larger entral artery immed tely lateral to the extravasation in ( )

Case 1 Woman aged 20 with a normal biopsy No immediate biopsy signs but selectiv nephroangiography th next day revealed a small leakage of contrast medium into the lower lateral part of the cortex nd a narrow defect running towards the surface this latter probably represented th needle track (Fig 1) in addition ma as visible along th lower lateral renal outlin Repeat biopsy was performed tv days later t obtain better preparation follo ed after another tw day again by selective ephroangio raph Th earlier defect persisted as slightly der than before and resembled p ripheral ischa m defect Th lo er pol of the kidney contained further small accumulation f ont medium surrounded by translucent zone (Fig 2)

Case Woman aged 22 ith histologic evidence of interstitial nephritis was examined by selectiv nephroangiography tv day fter biopsy with no abnormal signs The kidney as supplied by tv arteries an extra asation of contrast medium measuring 3 mm × 10 mm was present in the region of the lower artery (Fig 3 a) With spot of medium immediat ly laterally to th extravasation evident on examination of the larger pper artery (F g 3 b)



Fig 4



Fig 5

Fig 4 Case 3 Selective nephroangiography 4 days after biopsy Triangular ischaemic area in the cortex of the intermediate part of the kidney with small extravasation at the apex of the triangle

Fig 5 Case 4 Selective nephroangiography 2 days after biopsy Severe generalized pruning of the peripheral vessels Cortical ischaemic defects in lower pole of kidney Soft tissue mass evident around the puncture site along the renal contour

Biopsy in dogs and rabbits has revealed signs of arterial spasm extrarenal leakage of contrast medium linear defects suggestive of infarction and arteriovenous fistulas No wedge shaped cortical defects such as those in the material of LUNDSTROM and the present series were evident

Only two investigations into cortical defects in human subjects have been unearthed MENO & ELKIN observed small peripheral cortical defects in five of their 18 cases of nephroangiographies immediately following biopsy but they provided no illustrations LUNDSTROM detected in corresponding examinations in 21 of his 140 cases a lesion characterized by interruption of one or two interlobular arteries and—peripheral to this—a triangular nephrographic defect The defect reached the kidney surface and was always small

The present authors were unable to discover any signs of angiospasm in their material A peripheral ischaemic defect was evident in 12 of the 50 angiographies The finding confirmed the work of LUNDSTROM The defect was often accompanied by a small extravasation of contrast medium It was sometimes distinct and clearly demarcated



Fig 6 Case 5 Selective nephroangiography 3 days after biopsy) Early enous filling from peripheral fistula in the intermediat part of kidney b) Oblique Slightly lev ted capsular arteries probably due to small haematoma

Case 3 Woman aged 27 with a diagnosis at biopsy f glomerular ephritis selectiv nephroangiograph undertaken four days later was followed by no abnormal gns A triangular cortical defect with base and sides of about 10 mm had already appeared in the arterial phase (Fig 4)

Case 4 Woman aged 33 with diagnosis at biopsy of membranous nephropathy and in whom selective nephroangiography two day after the puncture revealed no bnormality The renal arteries ran an irregular course A triangular irregular cortical defect of slightly striated contour measuring about 15 mm × 15 mm × 10 mm lay in the lower pole f the kidney (Fig 5) A mass as evident around the puncture site running along the renal contour

The first angiographically demonstrated arteriovenous fistulas caused by needle biopsy of the kidney were reported in 1962 by BOIJSEN & KOHLER and FERNSTRÖM & LINDBLOM BENNETT & WIENER (1965) described 9 ase from a material comprising 58 needle biopsies Seven arteriovenous fi tul nephro-angiographically verified were analysed by EKELUND & LINDHOLM 1971 the nephroangiographies were performed after 48 needle biopsies These and the previously mentioned 22 cases described by LUNDSTRÖM are upported in the literature by only one or more cases per author Twelve of LU DSTRÖM s cases



Fig 7 (a b) Semi lectiv nephroangiography 7 day fter biopsy Large triangula parenchymal defect laterally in the intermediat part of kidney probably du to infarction Arteriovenous fistula with enous filling faintly discernible in inferior ena ca b) Selectiv nephroa iograph 10 day later The defect persists but is slightly smaller the fistula has losed

revealed arteriovenous fistulas immediately after biopsy and MENO & ELKIN reported 2 similar cases among their 18 cases subjected to angiography at a corresponding time Great deviation otherwi e occurs in the interval betw een the biopsy and angiography A great many cases were examined during the first week after the biopsy but angiography was sometimes not performed for 18 months following the renal puncture

EKELUND encountered arteriovenous fistulas one week after biopsy in 20 of 41 cases in experimental nephroangiographies following puncture of the kidneys in the rabbit Repeat angiography two months later disclosed that 14 fistulas had closed 3 had decreased in size and 3 were unchanged Neither SWEET et coll nor MULLER et coll in corresponding experiments in dogs were abl to demonstrate any arteriovenous fistulas



b

Fig 8 Case 7 Selective nephroangiography 2 days after biopsy) Catheter in an artery to the intermediate part of the kidney Large arteriovenous communication directly into inferior vena cava as early as the arterial phase b) Oblique The fistula lies deep in the renal parenchyma

Such fistulas were detected in 9 of the present 50 nephroangiographies The angiography was performed 2 to 3 days after biopsy in all but one case one in which the interval was seven days The biopsy needle had penetrated 2 to 3 cm within the renal contour in 5 cases in the remainder of the cases the fistulas formed about 10 mm under the renal contour The cases also had a triangular ischaemic zone around the site of the fistula Contrast medium leakage always occurred at the site although the fistulas otherwise varied considerably in both localization and size they were classifiable as small in 4 cases medium sized in 3 and large in 2 cases Four cases presented a mass in the contour around the puncture site definite over representation compared with the other cases Haematuria and pain in the side were also appreciably more frequent than in the rest of the material Hypertension was present in 6 cases Biopsy disclosed abnormality in 8 of the 9 angiographies



Fig 7 Case 6) Semi-elective nephroangiography 7 days after biopsy Large triangular parenchymal defect laterally in the intermediate part of kidney probably due to infarction Arteriovenous fistula with venous filling faintly discernible in inferior vena cava b) Selective nephroangiography 10 days later The defect persists but is slightly smaller the fistula has closed

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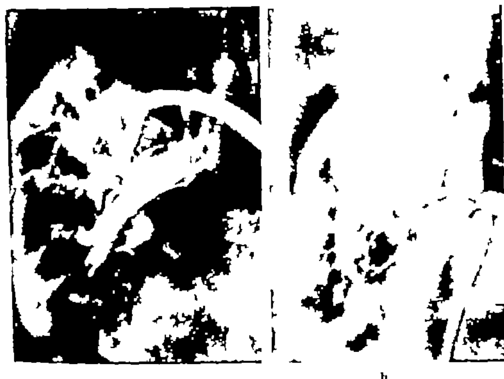


Fig 8 Ca 7 Selectiv nephroangiography 2 days after biopsy) Catheter in an artery to the intermediat part of the kidney Large arteriovenous communication directly into inferior ena cav as early as the arterial phase b) Oblique The fistula lies deep in the renal parenchyma

Such fistulas were detected in 9 of the present 50 nephroangiographies The angiography was performed 2 to 3 days after biopsy in all but one case one in which the interval was seven days The biopsy needle had penetrated 2 to 3 cm within the renal contour in 5 cases in the remainder of the cases the fistulas formed about 10 mm under the renal contour The cases also had a triangular ischaemic zone around the site of the fistula Contrast medium leakage alway occurred at the site although th fistulas otherwise varied considerably in both localization and size they were lassifiable as small in 4 cases medium sized in 3 and large in 2 cases Fou cas presented a mass in the contour around the puncture site definite over representation compared with the other cases Haematuria and pain in the side re also appreciably more frequent than in the rest of the material Hypertension was present in 6 cases Biopsy disclosed abnormality in 8 of the 9 ngiographies



Fig 9 Case 7 Aortal nephro-angiography f llowing the selectiv investigation Triple arteries t both kidneys w th fistul right kidney

Cas 5 Woman ged 53 with ev dence f tubular necrosis nd severe hypertension Pain referred to the kidney region occurred fter th biopsy and selectiv nephroangiography three day following t revealed a relatively superficial arteriovenous fistula f medium size w th a small ischaemic zone towards the periphery (Fig 6)

Case 6 Woman aged 19 w th evidence of proliferative glomerular nephritis at biopsy f llowed by abdominal and back pain with macro cop haematuria BP 140/100 mm Hg A perirenal haematoma was considered possible Selectiv ephroangiography was performed seven da s after the biopsy A relativ ly large wedge shaped defect the intermediat part of the kidney from th surface to depth f 25 mm was associated with fistula f medium size at the apex f the triangle A fairly large formation haematoma lik m ppearance lay along the lateral contour of the kidney (Fig 7 a) Selectiv angiography 10 day later demonstrated a persistent though somewhat decreased defect but no fistula and no haematoma (Fig 7 b)

Cas 7 Woman aged 58 with evidence of chronic inflammation of the kidney at histology and considerabl hypertension A sampl f urine after biopsy contained numerous erythrocytes Selectiv nephroangiography two day later revealed central arteriovenous fistula with a free flow int the inferior ena ca a (Fig 8) The kidney had multipl arteries Complementary aortography disclosed bilateral triple arteries (Fig 9)

Discussion

Biopsy is usually performed today under the control of TV fluoroscopy The biopsies in the present investigation were carried out by the previously mentioned method partly because of the radiation hazard The incidence of clinical complications was not high compared with other materials and this system seems in practice to be suitable

Extravasation of contrast medium in nephroangiography is probably to be expected after all biopsies when such a well vascularized organ as the kidney is perforated by a large cannula. The frequency of extravasation of medium was even high in LUNDSTRÖM's large material when the puncture was followed immediately by nephroangiography. An interval of just 2 to 3 days appears to change the situation. LUNDSTRÖM had a 73 per cent frequency of partly extra-renal extravasation, while only 24 per cent occurred in the present material, all being intrarenal. Large perirenal leakage of contrast medium was observed by LUNDSTRÖM particularly in connection with arteriovenous fistulas. The present cases with fistulas had no such leakage, but a soft tissue mass in association with the kidney contour was demonstrated in 4 of the 9 cases. Only 3 haematomas in all were present in the rest of the cases.

Clinical signs were insignificant or absent in all but one of the cases with bleeding. This agrees with the observations made by ZBCHORNAK et coll. as well as LUNDSTRÖM and contradicts the assertion of KARK et coll. (1958) that even a small haematoma will cause great discomfort. Peripheral cortical ischaemic defects immediately after needle biopsy are nephroangiographic changes that probably only LUNDSTRÖM has previously reported. Such changes in a few cases that were controlled later either persisted unaltered or disappeared. The changes had, however, increased somewhat in one of 2 of the present cases that were re-examined a few days after the first angiography, whereas they were slightly less in the other case. The cortical defect resembled infarction. Descriptions in the literature of renal infarcts caused by biopsy and revealed at post mortem examinations are infrequent. On the other hand, small scars on the surface of the kidney after puncture have sometimes been observed. The present investigation probably also fails to provide a definite answer to the question as to the exact cause of the cortical defects.

Reason on the whole appears to exist to count on fairly large individual variations in the sequelae to biopsy as indicated by the completely negative angiographic findings sometimes recorded. Most authors describe such cases in their series. It is worth noting that even ZBCHORNAK et coll. were unable to detect the puncture site in 5 out of 29 cases when they freed the kidney by operation at 2 to 4 days after the biopsy.

Arteriovenous fistulas occurred in 18 per cent of the present material. BENNETT & WIENER reported them in 17 per cent of their cases, EKELUND & LINDHOLM in 14 per cent and LUNDSTRÖM in 11 per cent of cases. The last mentioned stated that fistulas may appear and grow in size soon after biopsy and thus escape detection at the subsequent angiography. This is possibly why the incidence was higher in the present series than reported by LUNDSTRÖM. Fistulas have, however, a marked tendency to close in the longer term, as illustrated by

the present and many other published cases. As regards the formation of arteriovenous fistulas, it is worth remembering the observation made in animal experiments that needle biopsy causes fistulas in the kidney of the rabbit fairly readily but never in the canine kidney (EKELUND, MULLER et coll., SWEET et coll.).

A significant correlation has been established between the origin of an arteriovenous fistula and the puncture site. All of the illustrations given by BENNETT & WIENER had a puncture track that was deep and central. The puncture had been performed with the patient sitting, which can hardly be the most practical position for biopsy. Central punctures occurred as well in most of the fistulas reported by EKELUND & LINDHOLM and LUNDSTROM. Four of 9 punctures in the present material were superficial and only 10 mm from the surface of the kidney. The greater tendency for fistulas to form after central puncture is a natural consequence of the greater likelihood that the point of the needle may damage large vessels.

An increased tendency to fistula formation has also been considered to be associated with hypertension and more serious kidney diseases; all the patients with fistula in the series of BENNETT & WIENER as well as most of those of LUNDSTROM and the present cases had hypertension. LUNDSTROM had moreover to admit that serious angiography changes were significantly more common in the hypertonia group of his series than in the non-hypertonia group. No increased tendency towards complications, and especially arteriovenous fistulas in connection with renal disease, occurred in the present material. All the cases without biopsy changes disclosed by angiography had mostly glomerular nephritis of different types. The histology was sometimes normal with angiographic changes; this occurred even in a patient with an arteriovenous fistula.

A central puncture site and hypertension appear to be the main causes of the most serious complications, i.e. arteriovenous fistulas and haematomas. The frequency of sequelae represents in general a considerable range of fluctuation from author to author, but seems to have a common denominator. A small material of a relatively inexperienced worker appears usually to have a distinctly higher frequency of complications than a large series from the larger urology centres.

SUMMARY

A material of 50 renal biopsies in 48 patients was controlled by nephroangiography for up t week. No changes were observed in 19 examinations while an intrarenal leakage of contrast medium was revealed 10 times and peripheral ischaemic defects were evident on 12 occasions. Further complications are also reported. An increased tendency towards sequelae appeared to be associated with hypertension and central puncture of the kidney.

ZUSAMMENFASSUNG

Ein Material von 50 Nierenbiopsien bei 48 Patienten wurde durch Nephroangiographie bis zu einer Woche nach der Biopsie kontrolliert Bei 19 Untersuchungen wurden keine Veränderungen beobachtet während eine intrarenale Leckage des Kontrastmittels 10 mal und periphere ischämische Defekte in 12 Fällen festzustellen waren Über weitere Komplika tionen wird ebenfalls berichtet Eine steigende Tendenz für Folgerscheinungen scheinen mit Hypertonie und einer zentralen Punktion der Niere verbunden zu sein

RÉSUMÉ

Une série de 50 biopsies rénales chez 48 malades a été contrôlée par angiographie rénale dans la semaine suivant la biopsie On n' pas constaté de modification dans 19 examens une fuite intrarénale du moyen de contraste a été mise en évidence 10 fois et des lacunes ischémiques périphériques ont été mises en évidence dans 12 cas Les auteurs ont aussi constaté d'autres complications la fréquence des séquelles paraît augmentée dans les cas d'hypertension et dans les cas de ponction centrale du rein

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RENAL BLOOD FLOW DETERMINED BY ANGIOGRAPHY

G LINGARDH and B LUNDSTROM

In addition to providing morphologic data, nephroangiography can also give some idea of the renal circulation Thus various morphologic criteria such as the calibre of the renal artery and renal size have previously been proposed (LUDIN et coll 1967) as parameters for the estimation of the renal plasma flow Although the calibre of the renal artery is frequently reduced in chronic, atrophic renal disorders the conditions may vary in acute states It is a wellknown fact that the cortical circulation is often greatly reduced in acute renal failure despite the fact that the size of the kidney is unaltered or at times increased (HOLLENBERG et coll 1971) Consequently estimations of the renal blood flow based on such morphologic criteria as renal artery calibre or renal size are unreliable On the other hand a detailed analysis of the passage of contrast medium through the kidney might provide more certain information In the present report the data obtained from nephroangiography is compared with the renal blood flow as determined by the dye dilution method

Material Thirty selective nephroangiographies were assessed The material includes kidneys with normal parenchyma as well as kidneys with various parenchymatous disorders The clinical diagnoses were based on app ai a n ade upon completion of hospital investigations generally including ren l biop In t o

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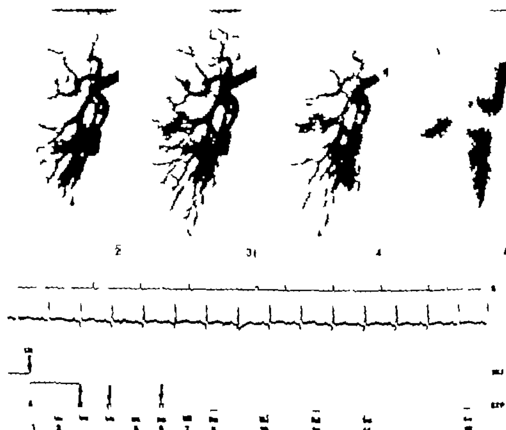


Fig 1 Normal selective nephroangiography with recording of time (in seconds) ECG injection time and exposure rate The distance between A and B represents the injection time C the exposure of film 4 in the series the last film with contrast medium remaining in the arteries Time from the start of the injection to film 5 is the arterial wash out time (2 1) D represents the exposure of film 6 the first film with contrast medium in the renal vein The distance between A and D represents the venous appearance time of contrast medium (6) RBF 560 ml/min by the dye dilution method

cases angiography was performed on normal kidneys in which the renal circulation had previously been reduced by injecting 10 microgram of adrenalin into the aorta

Methods Determinations of the renal blood flow (RBF) and venous appearance time of dye in connection with selective nephroangiography were carried out as described previously (LINGARDH et coll 1969 LINGARDH 1971 LINGARDH & LUNDSTROM 1972) In the nephroangiography 10 ml of contrast medium (Urografin 60 %) were injected by a pressure injector using a pressure of

ARTERIAL WASH-OUT TIME

5 3
4 3
3 7
3 2
2 8
2 1

RBF 450 450-350 350-250 250 ml/min

Fig 2 Relationship between arterial wash out time (in seconds) measured with the aid of recorded injection and exposure data and angiographic films and RBF determined by the dye dilution method Each kidney represented by □

5 5 kg/cm The resultant injection time was 1 0 to 1 1 s The rate of exposure was two films per second during the first four seconds followed by one film per second during another three seconds and a final film after an additional two seconds ECG injection and exposure data (Fig 1) were recorded on a polygraph The same film changer and pressure injector was used in all cases The rate of passage of the contrast medium through the kidney was assessed both by observing when the medium had completely disappeared from the intrarenal arteries and by noting the earliest time at which it could be observed in the renal vein These times were determined with the aid of the recorded injection and exposure data In the following account the time required for the medium to disappear from the intrarenal arteries will be referred to as the arterial wash-out time as suggested by ABRAMS (1972) The time from the beginning of the injection to the first film in which the medium begins to appear in the renal vein is called the venous appearance time of contrast medium Other designations for this such as circulation time and transit time are also used in the angiographic literature

In two cases the renal blood flow was measured after the injection of adrenalin and repeat angiography was done after further injection of adrenalin In connection with these examinations a separate arterial catheter had been introduced into the aorta The tip of this catheter was positioned about 8 cm above the origin of the renal artery After the catheter had been filled with the adrenalin solution and a short time had been allowed to pass in order to eliminate the possible effect of superfluous solution 10 microgram of adrenalin were injected through the catheter Dye dilution measurements were performed 5 after the injection of adrenalin After it had been ascertained with the aid of new curves that the effect of adrenalin had passed over nephroangiography was performed 10 to 15 min later this time also beginning 5 seconds after the injection of another dose of adrenalin

Table
Material

Renal blood flow (ml/min)	No. of examinations	Diagnoses	
> 450	14	Normal	14
450 – 350	8	Normal	9
		Epidemic nephritis	6
350 – 250	5	Glomerulonephritis	2
		Pyelonephritis	1
< 250		Glomerulonephritis	
		Nephrosclerosis	1
		Normal after injection of adrenalin	2

Results

The renal blood flow determinations by the dye dilution method revealed that the flow ranged from normal to greatly reduced values in the different examinations. These 30 examinations were divided into four groups according to the RBF values found (Table). On checking the exposure recordings the rate of exposure was found to be somewhat slower than the preset rate. Thus, the computed arterial wash-out time was corrected to 2.1 s, 2.6 s, 3.2 s, etc. (instead of preset 2.0 s, 2.5 s, 3.0 s, etc.). The relationship between the renal blood flow measured by the dye dilution method and the arterial wash-out time appears in Fig. 2. In the group with the RBF exceeding 450 ml/min the arteries were devoid of contrast medium after 2.1 seconds in 8 cases. In these examinations film 4 was the last film in which the medium was still present in the arteries and film 5 was the first in which they were devoid of contrast medium (Fig. 1). With renal blood flows of this magnitude the time was 2.6 s in 5 additional cases and 3.2 s in one case.

In the group with an RBF of 350 to 450 ml/min the arterial wash-out time was 3.2 s or more in 5 out of 8 examinations. When the RBF was less than 350 ml, the corresponding time was, as a rule, 3.7 s or more (Fig. 3). In the two cases in which adrenalin was injected, the RBF decreased to less than 250 ml/min. One of these examinations is demonstrated in Fig. 4. The angiographic findings in these cases with the adrenalin effect deviated only little from those of the other kidneys in this group (2 cases of glomerulonephritis and 1 case of nephrosclerosis). Thus, in all the examinations the intrarenal arteries decreased in calibre fairly suddenly subcortically, so that no filling of cortical arteries could be observed. In the two adrenalin cases the arterial wash-out time was 5.3 s.

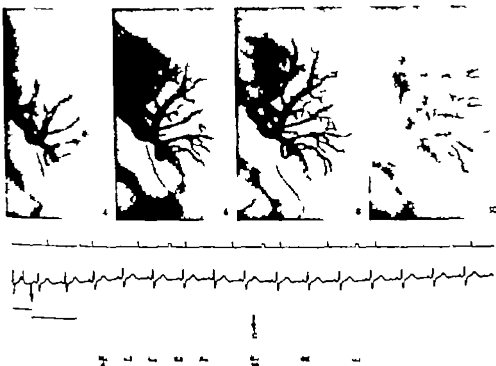


Fig 3 Films 4 6 8 and 10 from angiographic film sequence in case of glomerulonephritis Arterial wash out time 5 3 RBF 210 ml/min

In 10 examinations with an RBF of more than 450 ml/min initial contrast filling of the renal vein could be linked with a specific film in the angiographic film sequence In these cases the venous appearance time of contrast medium averaged 3 6 s (2 6 to 4 3 s) The appearance time in dye dilution determinations in corresponding cases averaged 2 9 s (1 8 to 3 9 s) In cases with severely reduced renal blood flow there was usually only a slow increase of contrast medium in the renal vein and the first film with medium in the vein could not be determined with certainty An exact computation of the appearance time of contrast medium was thus rendered impossible

Discussion

Under normal conditions the flow of blood to the renal cortex makes up 80 to 90 per cent of the total renal blood flow (Thorburn et coll 1963 Truniger et coll 1966 and others) If cases of severe stenosis of the renal artery are excluded with normal blood pressure and blood viscosity the renal blood flow is



Fig 4 Films 7 and 12 after intra rterial jection of adrenalin Arterial ash out time 5 5 RBF 180 ml/min

mainly dependent on the peripheral resistance of the renal vascular bed In recent years reduced blood flow through the cortical tissues has been demonstrated by means of examinations with xenon as well as other methods in various acute renal di orders such as tubular nephritis acute rejection of renal transplants and reactions to nephrotoxins (RETIK et coll 1967 HOLLENBERG et coll 1968) A form of active selective vasoconstriction in the cortex has been postulated in such cases (DANIEL et coll 1952 HOLLENBERG et coll 1971) In spite of reduced renal blood flow the kidney may sometimes be enlarged in these cases owing to parenchymal oedema In epidemic nephritis (nephropathia epidemica of Scandinavia) the blood flow to the kidney is of normal magnitude or slightly reduced despite the fact that the renal artery is dilated and the size of the kidney is frequently increased as the result of interstitial oedema (LINGARDH et coll in press) The angiographically measured size of the kidney and width of the renal artery therefore seem to be inadequate parameters for assessing the renal blood flow A recently suggested method for computing the RBF from the volume of the cortical tissue (GOTHLIN et coll 1973) is equally unsatisfactory

As has been shown by among others ABRAMS et coll (1962) and EPSTEIN et coll (1968) peripheral renal vasoconstriction can be induced by injection of adrenalin When angiography is performed under these circumstances reduced filling of the peripheral cortical vessels occurs ABRAMS (1972) al o points out the possibility of relating the renal blood flow to the contrast filling of such intrarenal

peripheral vessels as the arcuate and interlobular arteries Although reduced filling of the cortical renal vessels often exists in renal disorders with diminished renal blood flow an acute inflammatory renal disorder such as epidemic nephritis can *in direct contradiction to the rule lead to increased filling of the interlobular* v els (LINGARDH et coll in press)

As has been demonstrated by BOLIN (1966) the renal blood flow as well as renal function can be evaluated by means of densitometric measurements made directly from angiographic films In principle however differences exi t between th h r nal blood flow examinations and those performed in other vascular regions such as the brain BOLIN points out that in addition to varying with the renal fun tion the uptake of contrast medium in the kidney also depends on the in j cted amount of medium and the rate of injection used It is al o possible that the circulation time may be shortened in cases with impaired renal function if too large an amount of medium is used in relation to the renal blood flow Because of methodologic difficulties and uncertainty concerning the accuracy of the technique it has not come into more widespread clinical use

As has been demonstrated previously (LINGARDH & LUNDSTROM 1972) in dye dilution m asurements the appearance time for dye in the renal vein varies in different renal di eases Thus, as a rule conditions with low blood flow such as chronic pyelonephritis nephrosclerosis and glomerulonephritis generally dis played prolonged app arance times Consequently it would seem to be possible that determinations of the appe arance time of contrast medium in th renal vein could be used to estimate the renal blood flow in angiography If no renal disease was present, it was found that on an average the contrast medium began to appear 3 6 s after contrast injection The corresponding time after dye injection was 2 9 s In cases with impaired renal blood flow only a slow increase of contrast medium in the renal vein was noted In such cases the first film with medium in the renal vein could not be det rmined with certainty Even if the amount of injected medium was increased demonstration of the renal vein was insufficient when the renal blood flow was severely reduced Consequently estimations of the RBF based on assessment of the ous appearance time of contrast medium produce unreliable results in cases of r nal disease with impaired blood flow

Unlike the venous appearance t n of contrast medium the arterial ash out time can be determined in renal with impaired renal blood flow In cases with normal renal blood flow th a al wash-out time ranged between 2 1 and 3 ? s which agrees well with th al limits (1 5 to 3 s) found by ABRAMS (1972) With the exception f n ase the arterial wash out time was pro longed when the RBF was l th n 550 ml/min *The error in determinations of* the arterial wash-out time w th th technique and rate of exposure used here is less than 0 5 s during the most k ant part of the examination

Thus, in a simple manner the arterial wash out time seems to give a fairly good idea of the renal blood flow Since nowadays injection and exposure data are generally recorded in most departments where nephroangiography is performed the angiographic examination can readily be adapted also to provide information on the renal blood flow The rate of injection should be rapid enough to yield high contrast concentration in the intrarenal arteries If the injection is started at the same time as the first film is exposed as is the custom and the rate of exposure during the following seconds is two films per second it seems that the following rule of thumb could be established If the fourth film is the last one with contrast medium in the arteries, the renal blood flow is in all probability normal (arterial wash out time < 2.1 s) and, as a rule the sixth film represents a moderately reduced blood flow while the persistence of contrast medium in the arteries up to and including the tenth film indicates a severely reduced blood flow ($<$ 250 ml/min)

Even though the method proposed here for assessing the renal blood flow on the basis of the arterial wash out time only yields approximate values it should be suitable for use in the clinic Compared with the methods in which the RBF is calculated from the measured size of the kidney or the computed volume of the cortical tissue it has the advantage of being able to register such changes in the blood flow as are caused by altered peripheral resistance without a demonstrable change in the size of the kidney

Acknowledgement

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SUMMARY

The renal blood flow was determined by the dye-dilution method concurrently with selective nephroangiography in 30 examinations Different angiographic parameters for assessment of the renal blood flow are discussed The time elapsing from the start of contrast injection until the intrarenal arteries become devoid of contrast medium (the arterial wash out time) corresponded fairly well with the magnitude of the blood flow to the kidney Among other things estimates of the renal blood flow based on the arterial wash-out time take account of the circulatory conditions in the renal cortex and should therefore be of clinical value

ZUSAMMENFASSUNG

Der renale Blutstrom wurde gleichzeitig mit der Farbstoff Verdünnungsmethode und der selektiven Nierenangiographie in 30 Fällen untersucht Verschiedene angiographische Parameter für die Bestimmung des renalen Blutstroms werden diskutiert Der Zeitverlauf vom

Beginn der Kontrastinjektion bis zum Zeitpunkt zu dem die intrarenalen Arterien frei von Kontrastmedium wurden (die arterielle Wash-out Zeit) entsprach ziemlich gut der Grosse der Durchblutung der Nieren Unter anderem berucksichtigen Bestimmungen der Nieren durchblutung die auf der arteriellen Wash-out Zeit beruhen die zirkulatorischen Bedingungen der Nierenrind und sollten deshalb von klinischem Wert sein

RÉSUMÉ

Le debit sanguin renal a et determine par la method de dilution d colorants en meme temps que par la nephro angiographie selective au cours d 30 examens Les auteurs examinent differents parametres angiographiques pour evaluer l debit sanguin renal Le temps qui ecoule entre l debut d l injection de contraste jusqu ce que les art res intrarenales soient videes de moyen de contrast (l temps de la age arteriel) correspond assez bien a l importance du debit renal du em Entre autres choses les estimations du debit sanguin renal basees sur le temps de lavage rteriel tiennent compte des conditions circulatoires dans le cortex renal et devraient donc avoir un interet clinique

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THE ILIAC COMPRESSION SYNDROME

KJELL ÅKE JOHNSSON BENGT GOTHMAN and SAM NORDSTROM

The iliac compression syndrome (COCKETT & LEA THOMAS 1965) is a condition of venous congestion in the small pelvis starting at the confluence area and radiating to one of the legs The symptoms are predominantly left sided but may also occur on the right side The venous drainage from the legs is obstructed sometimes to such an extent that thrombosis may arise Depending on the localisation of the obstruction various channels of collateral circulation ar established Detailed investigations oncerning these problems have been carried out by LEA THOMAS et oll (196

The right common iliac art ry cros the left common iliac vein on the anterior aspect of the vein pproximat at the level of the promontory In frequently this intimate rel onship of tery and vein may result in venous obstruction MAY & THURNER 1956 ested that the back and front walls of the vein are brought int ntact wi h one another by means of transmitted arterial pulsations resultin n chronic nflammatory conditions of the vein

Endothelial proliferat ausing n rrowing of the venous lumen in the confluence area or its t have be recorded at autopsy Thus in 22 per cent out of 430 autopsi bnormalitie of the wall were found in the common iliac vein close to th onfluence ranging from slight, valvelike formations

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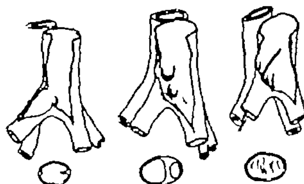


Fig 1 The distal part of the inferior vena cava and the confluence area seen from behind. Different degrees of occlusion of the venous lumen due to intimal proliferations from small shelflike formations to almost total obliteration of the lumen (Courtesy MAY & THURNER)

growing into the lumen from the medial and lateral sides to almost total occlusion of the venous lumen (MAY & THURNER, Fig 1) Histologically these changes were consistent with those appearing in chronic unspecific inflammation and in no case could they have been mistaken for a recanalized thrombus

The *symptoms* and signs are uncharacteristic in many cases consisting only of a slight to moderate *swelling* of the leg. Varicosities of the leg may occur but are not obligatory. Most cases are women usually young or in early middle life

This condition has previously been investigated by COCKETT & LEA THOMAS who performed pertrochanteric phlebography and by LEA THOMAS et coll (1968) who did separate phlebo- and aortographies under exactly comparable conditions. By means of a modified subtraction procedure the mutual relationships between vein and artery were well illustrated

Material and Methods During the years 1968 to 1971 this condition was encountered in seven patients all women. In the beginning the mode of examination was not uniform but has become so gradually and at present consists of the following procedures presented in the order in which they are performed

A Pelvic phlebography in supine position. Puncture of both femoral veins, insertion of teflon catheters connected by a Y tube and injection of 50 ml Isopaque Cerebral within 1 7 s. If obstruction to the inflow into the inferior vena cava is demonstrated resulting in filling of the left ascending lumbar vein or collateral circulation from the left to the right side via the presacral and parametrial plexus or the pubic vein, the examination is supplemented with a pressure recording

B Recording of the intravenous pressure is performed in supine position by means of the two injection catheters, which are placed in the inferior vena cava. They are then moved peripherally to each common iliac vein during continuous recording of pressure



Fig C 2) Pelvic phlebographs Compression on lef side just peripheral to the confluence Wide left lumbar ascendi g em filled Collateral circulation from left to right si the presacral plexus b) Simultaneous pelvic phlebography and aortography An overriding ft common iliac rtery is the cause of the enous compression

C Pelvic phlebography in prone position see further und r A

D Recording of the intravenous pre sure in prone position see further under B

E Simultaneous pelvic phlebographs and aortographs One femoral artery is punctured and a third catheter is inserted with its tip in the middle part of th abdominal aorta Simultaneous injection by means of two pressure syringes

Case reports

C se 1 A oman aged 29 had d l raceptives for 5 months and when admitted to ho pital had had s elling f th t or 2 da s Angiography revealed thrombosis in the lef ilia em w th th p the confluence Simultaneous phlebo- and aortography indicated con ider nous An iliac thrombectomy as performed but thrombos dev loped At ep operation local resection f the ein and artery as carried out and l g more than 50 per cent f the lumen of the ein was encountered A p l m f inserted in the ein and dacron graft the right il ac artery and the p ent without discomfort



b

Fig 3 Case 5 a Pelvic phlebograph early phase Left common iliac vein considerably wider than the right Collateral circulation from left to right in the presacral plexus Left lumbar ascending vein filled b) late phase Obstruction to inflow for left common iliac vein c) Simultaneous phlebo- and aortography The impression at the confluence area is caused by right common iliac artery

Case 2 A woman aged 30 had had intermittent swelling of the left leg for several years and mild varicose veins Simultaneous phlebo and aortography indicated compression of the left iliac vein Increased venous pressure on the left side The findings were confirmed at operation Adhesions between the vein and artery were loosened and the patient condition improved (Fig 2)

Case 3 A woman aged 49 had had swelling of the left leg for 2 to 3 years Angiography revealed arterial compression of the left common iliac vein and reduced inflow into the vena cava A collateral circulation from left to right was also present At operation severe stenosis of the left common iliac vein was found The obstruction to the venous flow was caused by the left internal iliac artery (LEA THOMAS et coll 1968) The left internal iliac artery was divided and the adhesions loosened and the condition improved

Case 4 A woman aged 45 had suffered from swelling of the left leg for 4 years Simultaneous phlebo and aortography revealed obstruction of inflow into the vena cava on the left side and a collateral circulation from left to right Venous compression with thickening of the venous wall was seen at operation After loosening of adhesions between the vein and the artery the condition improved

Case 5 A woman aged 18 had had moderate swelling of the left leg for 2 years Obstructed inflow and a collateral circulation from left to right were established by angiography At operation a fibrous band was found where the vein and artery crossed



Fig. 4. Same case as fig. 3. Operative findings. a) The left common iliac vein is congested and cyanotic; overriding of right common iliac artery evident. b) After loosening of adhesions and ligation of a rudimentary caudal artery the left common iliac vein is of ordinary size and appearance.



Fig 5 Ca 7) Phlebography Collateral circulation from left to right and venous compression in the confluence area Widening of the left common iliac in Left lumbar ascending ein filled b) Simultaneous phlebo- and aortograph The impression the left common iliac ein caused by the tortuous left common iliac artery

each other A rudimentary caudal artery binding the aorta bifurcation dorsall was divided A pressure gradient of 8 cm H O over the confluence area as recorded Adhesions ere loosened and the pres ure fell to normal after the operation Th patient as completely restored (Figs 3 4)

Case 6 A woman aged 19 had had swelling of the left leg for more than 2 years She had been taking oral contraceptives for 6 months before th investigation Angiography revealed enous compression with a collateral irculation from left to right Pres ur gradient left common iliac ein to ena cava 7 cm H O both in supine and pr ne positions Preoperati catheterization ith a Fogarthy catheter performed T s filled with 0 5 ml cont ast medium resulting in an outer diameter of the balloon f 9 hich just enabled the catheter to pass the constricted part of the vein. Both pr xim l and distally to this narrowed section the balloon could be moved freely filled with ml contrast medium corresponding to diameter of 15 mm The patient has not yet undergone operation

Case 7 A woman aged 42 with a history f swelling f both legs predominantl the left leg for 5 to 6 years Angiography established venous compression with collateral circulation from left to right Simultaneous phlebo and aortography Venous compression

bilaterally of haemodynamic significance of the l ft side Gradient 5 cm H O At operation congested pelv c eins were encountered especially presacrally The adhesions were loosened and following the operation the venous congestion diminished noticeably (Fig 5)

Discussion

Reports based on large surgical and roentgenologic materials of ileofemoral thrombosis indicate that this condition is more common on the left than on the right side occurring approximately in the ratio of 4 1 to 5 1 and that venous congestion is eight times more common on the left than on the right side (Bales & De Weese 1966) Since the artery constricts or compresses the iliac vein predominantly on the left side it seems reasonable to suggest that such a mechanism might contribute to congestion of the femoral vein and thrombus formation

Oral contraceptives may play a role because such medication may cause intrinsic lesions of the veins in the form of endothelial proliferation and intimal thickening (Irey et coll 1970) and increase the propensity of blood for thrombus formation (Ask Upmark 1966 Vessey & Doll 1968) These mechanisms might account for ileofemoral thrombosis having developed shortly after administration of oral contraceptives as demonstrated in one of our patients

In view of the fact that seven cases have been observed during a three year period at one and the same hospital and observations in the literature concerning this condition are rather few it is surmised that the condition is more common than was formerly believed It is evident that a correct diagnosis is important since the disorder can be successfully treated When no abnormalities are encountered at peripheral phlebography performed for possible venous congestion or deep thrombosis supplementary examinations of the pelvic veins, including the confluence and the arteries around the promontory should be carried out These angiographic examinations should also be supplemented with pressure recordings in the inferior vena cava as well as in the iliac veins in order to obtain a better understanding of the functional significance of the anatomic abnormality demonstrated angiographically

SUMMARY

Th iliac compression syndrome is condition of venous congestion in the small pelvis due to rterial compression f th eins Seven pati ts ith this condition d demonstrating many clinical and roentgenologi features in ommon are presented The etiology indications and technique f examination are dis ussed as well as the role f oral contraceptives as thrombogenic factor

ZUSAMMENFASSUNG

Das vom Darmbein gehörige Kompressions-Syndrom beruht auf einer venösen Stauung im kleinen Becken infolge einer arteriellen Kompression der Venen. Sieben Patienten mit einer derartigen Veränderung, die im allgemeinen viele derartige klinische und röntgenologische Gesichtspunkte zeigen, werden vorgestellt. Die Aetiologie, die Indikationen und die Technik der Untersuchung sowie die Rolle der oralen empfängnisverhütenden Mittel als Thrombose hervorrufender Faktor werden diskutiert.

RÉSUMÉ

Le syndrome de compression iliaque est un état de congestion veineuse dans le petit bassin du à la compression des veines par les artères. Les auteurs présentent sept malades atteints de cette affection qui ont en commun de nombreux caractères cliniques et radiologiques. Les auteurs examinent l'étiologie, les indications et la technique d'examen ainsi que le rôle des contraceptifs oraux comme facteur thrombogénique.

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SCLEROSING INJECTION OF ESOPHAGEAL VARICES THROUGH TRANSHEPATIC SELECTIVE CATHETERIZATION OF THE GASTRIC CORONARY VEIN

A preliminary report

A LUNDERQUIST and J VANG

The mortality due to bleeding from esophageal varices is high in patients with portal hypertension (HISLOP et coll 1966 ORLOFF 1967) and only 30 to 50 per cent of patients are reported to leave hospital after the first hemorrhage. Emergency operation with a portal systemic shunt in these debilitated patients is likely to give poor results

Transhepatic portography in cases with portal hypertension has been used in this department to demonstrate the venous anatomy preoperatively (GOTHLIN et coll 1974) During this procedure the coronary vein was found easily available for selective catheterization This was the incitement to try injection of a sclerosing agent in this vein for emergency treatment of bleeding esophageal varices

Method and Material Transhepatic puncture of the portal vein was performed under local anesthesia through the lateral thoracic wall by the usual

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Fig 1 Transhepatic portography in woman aged 8) th liver cirrhosis Retrograde flow through coronary ein to esophageal arices through inferior mesenteric ein and para umbilical eis



Fig 2 Selective atheterization of coronary vein th injection of contrast medium gives better demonstration of the rices



Fig 3 I jection of contrast medium into co onary ein after thrombosization N rices fi lled



Fig 4 Po tography No retrograde filling of the coronary ei now oblite t d by thrombus Contrast medium in the thrombus (→) fter the previous inject on

technique for transhepatic cholangiography. After the needle had been pulled out a guide wire was inserted into the main stem of the portal vein. The catheter was then placed with the tip in the medial portion of the splenic vein. With the catheter in this position 40 ml of Isopaque Coronar was injected. Exposures were made one per second for 8 s and one every other second for 16 s. This allowed the vascular anatomy and flow directions to be demonstrated.

When retrograde flow through the coronary vein was observed and the varices in the fornix of the stomach and the lower esophagus had filled a curved guide wire was introduced through the catheter and manipulated into the coronary vein to the branching close to the cardia. A catheter could then easily be placed with the tip at the same site. Contrast medium was again injected to obtain better information about anatomy and flow directions. When the flow was directed to the esophageal varices 30 ml of glucose 50 % was injected manually through the catheter to produce an intimal injury to the vein, after which the catheter was filled with thrombine solution (Topostasin, Roche, Switzerland, 3000 NIH U. in 10 ml saline). A few drops only were then injected into the coronary vein, where a thrombus was immediately formed. The result was checked with a hand injection of contrast medium. When the blood flow through the esophageal varices was blocked by the thrombus small fragments of spongostan (Ferrosan, Denmark) were injected through the catheter into the thrombus in one case. Two patients only have been treated up till now.

Case report

A woman aged 65 was referred to the hospital with severe hematemesis and melena. After insertion of a Sengstaken-Blakemore tube and blood transfusions the bleeding stopped. Three years previously liver cirrhosis with ascites and esophageal varices had been diagnosed. During these three years the patient had been hospitalized seven times for severe bleedings from her varices but her condition had not allowed operation. On admission her condition was bad and the anesthesiologist advised against operation under general anesthesia.

At transhepatic portography (Fig. 1) wide esophageal varices were filled through the coronary vein which was then catheterized (Fig. 2) and thrombosed (Fig. 3). At subsequent portography (Fig. 4) no filling of the coronary vein or esophageal varices was obtained. The patient has had no recurrence of her bleedings and left the hospital after one week. The subsequent observation period has been short, only two weeks.

Discussion

The treatment of esophageal varices by injection of a sclerosing agent is not new and was first described by CRAFOORD & FRENCKNER (1939). They made the injection through an esophagoscope. This method has later been used by FEARON & SASS-KORTSAK (1959), ORLOFF (1967), and HUNT et coll. (1969).

Fibrosis and thickening of the esophageal wall has been produced by intra mucosal sclerosing injection through an esophagoscope in inoperable patients with bleeding esophageal varices (KAPP & BUZAS 1973)

The injection of hypertonic glucose and thrombine into the coronary vein in the present case was intended to stop the acute hemorrhage By blocking the esophageal route of portal systemic communication other possible spontaneous anastomo es as the inferior mesenteric vein spleno-renal anastomoses and para umbilical vein anastomoses to subcutaneous veins may increase in size The need for spleno-renal or porta-caval shunts may then be reduced As emergency portal systemic hunts involve a high mortality a non-operative method of treatment should be preferable

SUMMARY

Bleeding from esophageal varices was treated by selectiv injection of sclerosing agent in the transhepatically catheterized gastric coronary ein A preliminary report is given I the technique and results in the first tw patients

ZUSAMMENFASSUNG

Blutungen on Oesophagusvarizen wurden durch selektiv I jektion on Sklerose hervorrufenden Mitteln in die transhepatisch katheterisierte Vena coronaria entriculi be handelt. Es wird ein preliminarer Bericht uber die Technik und die Ergebnisse bei den ersten beiden Patienten gegeben

RÉSUMÉ

Une hemorragie de rices oesophagiennes et traitee par injection selectiv d un agent derosant dans une eine coronaire stomachique catheterisee par oie transhepatique Les auteurs presentent un rapport preliminaire sur leur technique et sur les resultats chez leur deux premiers malades

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CHRONIC SYMMETRIC OSTEOMYELITIS

Report of a case

K H GUSTAVSON and H F WILBRAND

GIEDION et coll (1972) under the heading Subacute and chronic symmetrical osteomyelitis described symmetrically distributed osteolytic changes in metaphyseal structures of the lower extremities in four children The age at onset of the main initial symptoms of limping pain local tenderness and swelling was 5 to 11 years there were no general symptoms apart from occasional periods of fever The time interval between manifestation of the first symptoms and the roentgenologic diagnosis varied between 5 weeks and 2 years The laboratory findings were unspecific and suggestive of inflammation The cultures of pretreatment biopsy material were negative in 3 of the patients but plasma cellular osteomyelitis was diagnosed histologically In the fourth case pneumococci were demonstrated in the biopsy cultures Healing occurred after long term treatment by sclerosis over periods varying from several months to some years

A further report of a girl with chronic symmetric osteomyelitis of the type described by these authors is now presented

Case report

A girl aged 7 years the second of four siblings in healthy family with no history of joint or skeletal diseases had developed normally she sustained slight trauma of the right

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Fig 1 Chronic symmetric osteomyelitis in the femoral and tibial metaphyses of both legs) Right leg Multiple roundish and columnar osteolytic foci in the metaphyses adjacent to the epiphyseal growth plates Periosteal reaction medially Sclerosis surrounds the osteolytic foci Cortical defect evident in femoral epiphysis b) Left leg Osteolytic foci in the femoral and tibial metaphyses with some perifocal sclerosis no periosteal reaction no clinical signs

knee which during the following three weeks became moderately stiff with some pain but no swelling no general changes The symptoms continued on and off for five months until she was admitted

On admission her general condition was good and she was completely free from symptoms there were no signs of infection and the condition of the joints was normal The girl was of normal height for her age Skeletal roentgenograms revealed bilateral osteolytic changes in the distal femoral metaphyses and the proximal tibial metaphyses (Figs 1 2), in the upper metaphysis of the right humerus (Fig 3) and bilaterally in the ischiopubic synchondroses (Fig 4)

Routine blood and urine tests were normal apart from an ESR of 25 to 26 mm The white cell count was 7 100/mm³ with 5 100 polynuclear and 2 000 mononuclear leukocytes and a differential count of 6 5 per cent eosinophils Liver function tests produced normal results The serum acid and alkaline phosphatases the serum calcium and phosphorus and the calcium and phosphorus excretions in a 24 hour urine specimen were all normal The serum electrophoresis the sheep cell agglutination test latex test and antigammaglobulin test were also all negative The antistreptolysin titre (AST) was less than 70 units/ml and the antistaphylococcal titre (ASTA) 4 0 units/ml A diagnosis of osteochondrosis juvenilis (CAFFEY 1967) was made and no treatment was prescribed

The patient was readmitted three years later She had had no symptoms since her previous stay in hospital apart from during the last month when she had had aching in the right knee and groin The ESR had been between 14 and 40 mm during she was at home On admission physical examination revealed nothing abnormal Roentgenograph indicated regression of the osteolytic lesions with increasing sclerosis Routine analyses of



Fig 2 Osteolytic lesions eroding the cortical and subcortical bone coalescent with a large defect in the popliteal region of the right knee. The osteolytic foci are surrounded by sclerosis.



Fig 3 Chronic osteolytic lesions in the upper metaphysis of the right humerus. A lesion lies adjacent to the growth plate with several lesions coalescent with a larger defect surrounded by sclerosis.

the blood and urine produced normal results. The white cell count was 5 600/mm³ with 3 700 polynuclear and 1 900 mononuclear leukocytes. ESR 27 mm. AST less than 64 units/ml and ASTA 1 6 units/ml. Blood culture was negative. Serum electrophoresis presented a pattern compatible with a low-grade process with immunoglobulin response. Metabolic screening of the urine revealed nothing abnormal. Biopsy was not indicated from an orthopaedic point of view.

She was re-examined two years later following bouts of pain immediately above and below the patella of the right knee especially when walking. There had been no swelling or increase in warmth of the knee but on a few occasions she had complained of pain on the outer aspect of the right hip, the right [illegible] of the lumbar spine and on the anterior aspect of the right tibia. three months previously she had had such severe pain in the right knee that she had been unable to bear weight on the leg. Joint function was normal when she was examined apart from slightly reduced outward rotation of the right hip due to pain and some atrophy of the quadriceps and tibial muscles of the right leg. Serum electrophoresis presented a pattern compatible with a chronic process with moderate signs of activity. The ASTA was 5 6 to 10 0 units/ml. ESR 19 mm and white cell count 7 600/mm³ with 4 300 polynuclear and 3 300 mononuclear leukocytes and a differential count of 6 per cent eosinophils. Serum immunoglobulin electrophoresis normal, blood culture negative. Biopsy two months later of the proximal part of the tibial metaphysis revealed partly devitalized bone tissue with infiltration of plasma cells. Bacterial and TB cultures from the tissue were negative. Pharyngeal cultures and blood cultures were also negative. ASTA 8 0 units/ml. Mantoux 2 TU positive. Blood group 0 Rh (+). Isoagglutinin A antibody titre 1/60. Quantitative serum immunoglobulin assay disclosed an increased IgE con



Fig 4) Osteolytic foci bilaterally around the ischiopubic synchondrosis b) One year after the onset of the disease chronic osteomyelitic foci present in th left pubic bone adjacent to the symphysis Regression of lesions in the bone round the right ischiopubic syndesmosis

entration but normal concentrations of IgG IgA and IgM Eosinophils 288/mm³ blood Direct and indirect Coomb tests were negativ l pus erythematosus (LE) test also negative N antinuclear f ctors in the serum could be detected There ere no serum ant bodies directed gainst smooth muscl cytoplasmic thyroid antigen renal glomeruli or mitochondria

A diagnosis of chron symmetric osteomyelitis was mad and a course of Kloxacillin initiated This had t be discontinued after 19 days however because of the development of general urticaria lincomycin was therefore substituted for a period of ten weeks Since about this tim the patient has been free from symptoms part from generalized urticaria which dev loped after taking an oral contrast medium for cholecystography and following local anaesthesia for dental treatment N abnormalities of th joints ha been evident at repeated linical examinations up t the present time Th muscular trophy in the right leg has regressed completely The ESR ASTA and serum electrophoresis as well as the roentgenographic findings have gradually becom normal

Sever allergic reactions t arious substances prompted recent examination and disclosed a raised serum concentration f IgE (870 units/ml) eosinophils 488/mm³ and positive intracutaneous tests to dog cat horse cow and t fish house dust and birch pollen

The patient has had periodi pain in the right side of the bdomen Oral cholecystography and urography rev ealed nothing abnormal A cyst f th right ovary was recently removed There were no further abdominal symptoms after th operation

Radiology

Right and left knees On first admission symmetric roundish or columnar o teolytic lesions with thin surrounding zones of sclerosis were evident in the lower femoral and upper tibial metaphyses not obviously invading the epiphyses (Fig 1) Partial destruction of the cortex of the popliteal aspect of the right femoral metaphysis with periosteal reaction was evident (Fig 2) One year

later progressive changes with sclerosis and osteolytic foci were observed followed after another year by regression of the latter and an increase in the former

Six years after the onset no osteolytic lesions persisted The trabecular structure of the right knee had signs of repair and the medial part of the metaphysis adjacent to the epiphysis still exhibited an irregular appearance with a predominance of sclerosis This was particularly evident in the left knee although some small osteolytic foci remained in the medial part of the metaphysis near the growth plate the cortex overlying the lesion had a speckled appearance

Seven years after the onset of the disease the roentgenologic appearances were entirely normal

Right humerus (upper end) Partly coalescent osteolytic foci surrounded in part by sclerosis, in the proximal end of the metaphysis of the humerus with some erosion of the cortex (Fig 3) Slight periosteal bone proliferation evident

One and a half years after the onset the lesions had completely disappeared and the bone structure had been remodelled to the normal with no signs of previous derangement At closure of the epiphyseal growth plate at the upper end of the humerus the metaphysis had a normal appearance

Pelvis On admission small roundish osteolytic foci were present symmetrically in the rami adjacent to the ischiopubic synchondrosis with partial erosion of the cortex (Fig 4 a) One year after the onset the lesion on the left side had become more extensive with osteolytic involvement, consisting of thickening and more sclerosis of the left symphyseal structures of the pubic bone (Fig 4 b) A year later a reduction in the size of the osteolytic lesions occurred The bone structure on the right side now appeared normal

Six years after the onset all the lesions had disappeared

Discussion

Subacute and chronic symmetric osteomyelitis is characterized roentgenologically by multiple osteolytic and sclerotic lesions in symmetric bone metaphyses (Giedion et coll) The distal femoral metaphyses and the proximal and distal tibial metaphyses as well as the sternal ends of the clavicles are particularly affected The symptoms at onset are usually unilateral with lameness and swelling or tenderness over the metaphyseal region affected Apart from occasional short episodes of fever generalized symptoms are unusual both initially and in the subsequent course of the disease When untreated the disease may last for several years with intermittent symptoms The laboratory findings are unspecific The ESR is moderately elevated and the number of leukocytes in

the peripheral blood is normal or slightly raised GIEDION et coll reported that biopsy material in three out of four instances revealed plasma cellular osteomyelitis these 3 cases presented no evidence of bacterial growth

The disease in the present case was considered initially to be one of juvenile osteochondrosis The subsequent course, however with periodic symptoms mainly from the right knee, bilateral roentgenologic lesions in the metaphyses typical of chronic osteomyelitis an ESR constantly elevated and a serum electrophoresis pattern compatible with a low grade process with immunoglobulin response was suggestive of chronic symmetric osteomyelitis (GIEDION et coll) A similarity appears to exist in the roentgenologic findings between the 4 cases described by these author and the present case (GIEDION personal communication) as well as the close resemblance to a case of osteochondrosis or low grade destruction osteomyelitis reported by CAFFEY (1967) The clinical course of the present case as well as the appearances and evolution of the roentgenologic findings resemble case I of GIEDION et coll The two differ however in the localization of the bone lesions which in the present case was similar to that of cases II and III of GIEDION et coll Osteolytic lesions in the proximal metaphysis of the humerus as in the present case were not evident in the previously reported cases of subacute or chronic osteomyelitis The pelvic lesions in the present case resemble those of osteochondropathia ischio pubica a disorder with a variety of possible pathogenetic factors (POSCHL 1971)

The pathogenesis in chronic symmetric osteomyelitis is not clear Three of the 4 cases reported by GIEDION et coll had negative biopsy cultures which does not however exclude a bacterial origin the biopsy culture of the fourth case in which the disease was subacute produced a growth of pneumococci

The biopsy culture in the present case was negative, but the histology indicated a chronic inflammatory process thus may have represented staphylococcal osteomyelitis of low virulence Supporting this possibility were the constant elevation of the ESR and ASTA titres before antibiotics were given as well as the rapid disappearance of the symptoms once this therapy had been instituted with a return to normal of the ASTA and ESR The immunologic examination revealed no evidence of reduced cellular or humoral immunity suggestive of an infection disposing factor GIEDION et coll postulated that chronic symmetric osteomyelitis might be an auto immune disease of bone laboratory examination revealed nothing to indicate autoimmune disease in the present case

The diagnosis is based to a large extent on a proper evaluation of the radiographic findings in skeletal disease with vague clinical signs such as subacute and chronic symmetric osteomyelitis It is possible for subacute and chronic osteomyelitis to pass unrecognized and to persist without a correct diagnosis and adequate treatment

SUMMARY

A case of chronic symmetric osteomyelitis in a girl is reported The clinical course and radiologic findings are described and discussed

ZUSAMMENFASSUNG

Bericht uber einen Fall von chronischer symmetrischer Osteomyelitis bei einem Madchen mit Beschreibung und Besprechung des klinischen Verlaufes und der Rontgenbefunde

RÉSUMÉ

Presentation d un cas d osteomyelite chronique symetrique chez une fille Description et discussion de l evolution clinique et des signes radiologiques

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DENTAL ROOT FRACTURE DIAGNOSED BY POLYTOMOGRAPHY

M HAVERLING and G RAMSTROM

Fractures of the dental roots usually do not provide difficulties of diagnosis being easily discovered at a conventional roentgen examination if they are not clinically revealed However in rare cases the fracture may be thin or oriented in a plane running in cranio caudal or lingual buccal directions, and tomography is then required The basic prerequisite for this type of examination is access to a tomograph unit with hypocycloid motion delivering thin cuts of high quality

Case report

A woman aged 25 was kicked in the face by a horse On clinical examination fractures were revealed in the crowns of the second and third teeth of the upper left jaw Tooth number four was luxated A fracture in the root of the fifth tooth was later suggested the tooth being tender on percussion Conventional roentgen examination two months after the accident revealed a minor deformity suggestive of a fracture of the root (Fig 1) The fracture was demonstrated unequivocally

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Fig 1 A minor deformity of the root of the tooth suggesting fracture

Fig The root fracture demonstrated by polytomography in both lingual buccal left and distal mesial right projections

Fig 1 Fig

by tomography serial tomograms 0 5 mm apart were taken in straight lingual buccal and distal mesial projections (Fig 2)

Discussion

It is not possible to examine a single isolated tooth in two perpendicular planes with the conventional roentgen technique since this does not allow a distal mesial projection This means that a fracture running an oblique or a spiral course in a lingual buccal plane is not always discovered when directed cranio-caudally It is well known that the anatomy of exceedingly small structures of the human inner and middle ear may be analyzed by polytomography Mündnich & Frey 1959 Brünner & Brahe Pedersen 1971) The precision of this method is evidently such that even thin fractures in a tooth may be demonstrated

SUMMARY

Tomography using hypocycloid m nt for the diagnosis f dental root fracture not clearly revealed at conventional ro tg graphs is described and the potential value f tomography for this purpose is emphasiz

ZUSAMMENFASSUNG

Die Tomographie unter Verwendung er hypocycloiden Bewegung zur Diagnose einer in konventioneller Röntgenaufnahme nicht deutlich nachweisbaren Zahnwurzel Fraktur wird beschrieben und der m k Wert der Tomographie fur diesen Zweck her vorgehoben

RÉSUMÉ

Les auteurs decrivent la tomographie hypocycloidale pour le diagnostic de fracture d une racine dentaire qui n avait pas ete clairement mise en evidence par la radiographie ordinaire Il insiste sur l interet possible de la tomographie pour ce diagnostic

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HIGH VOLTAGE RADIOGRAPHY

Theory and clinical application

S REICHMANN and C G HELANDER

Efforts made a decade or more ago to adapt radiographic procedures to high tube potentials (MATTSSON 1955) were not universally successful. Low voltage is still employed today in skeletal radiography as well as in examinations with iodine contrast media. Chest radiography at a tube potential of 200 kV was tried in the early 1960s in several Swedish centres; however, only a few clinics now retain this technique (STRAND 1973). The only fields were those of barium sulphate examinations of the gastro-intestinal tract and gas myelography.

Nevertheless considerable advantages may be obtained with the high voltage technique provided one important matter can be solved. These consist of short exposure times, reduced tube load, short intervals between exposures and possibly reduced patient dose. The problem to be solved is complex. Broadly speaking it concerns impaired contrast and possible ways of improving it.

Radiography may now be considered from the aspect of two distinct categories: signals and noise (SCHOBER 1962, ROHLER 1962, MORGAN 1966). Signals constitute the information desired but noise is always objectionable. As with sound, noise disturbs the ability to perceive weak signals. Thus image elements

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of low contrast (low signal intensity) always stand the risk of being obscured by the noise to a degree as to become imperceptible

Secondary radiation is one important type of noise, since it consists of radiation without any information about the object However even primary radiation may contain noise One aspect of this latter noise is quantum mottle which is due to the fact that primary radiation consists of discrete photons (= quanta) The image is formed by a limited number of such photons and their information is not evenly distributed over the film but varies randomly this is due to the statistical chance of each photon being ab orbed in the recording medium The background tends thus to become irregularly blackened even in places where it should be completely homogeneous Increased sensitivity generally gives rise to an image built up by a smaller number of photons, which means increased quantum mottle (= increased statistical chance of local variations in absorption) However if the increase in sensitivity be due solely to an increased ability of the film or screen film combination to absorb roentgen photons the quantum mottle will not increase (REICHMANN 1974) To the quantum mottle is added structure mottle caused by the crystal structure of the intensifying screens If this structure be inhomogeneous the fluctuations in roentgen photon absorption will be larger than pure quantum mottle alone (CLEARE et coll 1962 REICHMANN & HELANDER 1974) This means that a coarse grained screen will increase the tendency towards uneven background blackening One purpose of the present report is to suggest that the graininess of the film is another significant type of noise

A signal may be so weak as to become completely obscured by the noise, the latter being simply an overall term for undesired signals without information about the object A well known example presents itself in the Bucky grid being removed during radiography of the abdomen many details normally visible will then disappear completely and at the same time the image contrasts will be reduced A more hard working film used in an attempt to counteract the impaired image quality will improve the signals and the noise to an equal degree (REICHMANN 1974) since noise also is a kind of signal The details that became invisible will thus not reappear in the high contrast image The only adequate way out is to reduce the noise i e to reinsert the Bucky grid A similar analysis may be made for other types of noise as well so that it may be generally stated that if image elements of very low contrast are to appear the noise level should be lowered

The signal intensity in high voltage radiography is decreased due to decreased absorption differences in the object Often the noise is also increased owing to an increase in the secondary radiation This means an impaired signal/noise ratio and a loss of low contrast detail one that cannot be compensated for by

Table

Screen film combinations used in the examination of a femur specimen at 120 kV

Film/Screen	Saphir	X-omatic Regular
Curix RP	X	X
X-omatic General		X
Medichrome	X	X
Memory T3		X

more hard working film The quality loss is so severe as to preclude the present day use of high voltage radiography except when barium sulphate is used and the absorption difference is large enough to produce sufficient signals

Secondary radiation is however only one type of noise The question remains whether the impaired signal/noise ratio can be improved by means of a lowering of the other noise types As regards structure mottle such a reduction may be obtained by using Kodak X-omatic screens (REICHMANN & HELANDER 1974) The quantum mottle may be brought to an appropriate level by changing the film sensitivity The influence, if any of film graininess on the total noise level must however still be determined This factor has been dealt with and has led to the selection of a suitable screen film combination this has been tested in some clinical fields of low voltage examination (skeleton urography and cholecystography) mostly utilizing a tube potential of 120 kV

Experimental

The first problem to be tackled concerned the noise inherent in the radiographic film If the signal intensity be decreased then the threshold of the contrast perceptibility of the film should be as low as possible if it be very low weak signals may be expected to appear in spite of their low intensities

The perceptibility threshold of different radiographic films cannot be obtained with the films exposed in a cassette since the quantum mottle of the roentgen rays may then set the threshold higher than effected by one or more of the films Likewise the films cannot be exposed directly to roentgen rays since the different energy contents of light photons and roentgen photons will give rise to an important source of error (BACKSTROM & LUNDH 1959) A film intended for exposure to visible light should be tested by means of light thus such films can not be tested by any form of radiography The following method was chosen It was assumed that the perceptibility threshold is correlated to the graininess of the film so that fine grain makes for a low threshold (fine grain = low noise i e a



b

Fig 1 Part of femoral neck of macerated specimen 11 cm of water Tube potential 120 kV The screen film combinations re a) Siemens Saphir/Agfa Cevaert Curix RP b) Kodak X omatic Regular/Kodak X omatic General) Kodak X omatic Regular/Agfa Cevaert Medichrome N ise lev l is lowest in)



b

Fig 2 Films expo d t 120 kV) H p joint 1) and) f fth l mbar ertebra lateral project on 11 p tient in) wa ma kedly obese and had senile osteopenia Richness in d tail f bone t acture

favourable signal/noise ratio) An original image with very weak signals was produced in a low sensitive film with a fine grain—Kodak Kodalith Ortho type III This original image was copied onto the roentgen films to be tested by means of ordinary photographic contact copying The following films were tested Kodak RP/R, Agfa/Gevaert Curix RP Kodak X omatic High and X-omatic General, Kodak RP/F X omat Flurospot, Agfa/Gevaert Medichrome and Agfa/Gevaert Mamoray T3 The first five films are 90 second films the last of them being intended for the 70 mm camera they were developed in a 90 second roll machine The Medichrome film was developed by a 2 5 minute process in a roll machine The Mamoray film has a low sensiti e industrial emulsion with a high silver content it was developed by a 6 minute process in a roll machine (cf DEICHGRÄBER et coll 1974)

The 90 second emulsions all produced impaired rendering of such detail in the original image as was faint but still visible The Kodak X-omatic General film produced somewhat better recording than the other films in this group its sensitivity also being the lowest of the double emulsion 90 second films The impaired recording occurred despite the fact that the general contrast was greater in the roentgen film than in the original image The industrial film rendered clearly even signals that were only just visible in the original image The Medichrome film did not have the same low perceptibility threshold as the industrial film however properly exposed, the films were not very different The maximum capacity of the Medichrome film was reached only when the film was inspected through a red filter The difference in detail rendering between the films is not reproduced in the present report owing to technical difficulties

The grain size of all emulsions was examined by microscopy The 90 second emulsions were similar although the X-omatic General film had a somewhat finer grain Medichrome film (after black and white development to produce the silver grains that precede the colour grains) and the Mamoray T3 turned out to have significantly finer grain without any great difference between them

One important conclusion may be drawn from these tests The ultimate threshold of perceptibility in radiography is seldom determined by the visual organ since everyday roentgen films may display a noise that sets the threshold at a significantly higher level A prerequisite of high voltage radiography is a film that can reproduce signals down to the threshold of human perceptibility

The second phantom test series was based on radiography of a macerated femur bathed in water The bone lay in a plastic basin under a water level of 11 cm and radiography was performed at 120 kV Two types of intensifying screens were used Siemens Saphir high structure mottle) and Kodak X-omatic Regular (low structure mottle) Most of the films presented in the first phantom test were included The screen film combinations are listed in the Table The



Fig 3a



Fig 3b



Fig 4

Fig 3 Urogram recorded at 120 kV a) after a normal dose of contrast medium and b) after 5 of normal dose

Fig 4 Cholecystogram recorded at 90 kV Normally concentrating gallbladder with stones

results confirmed the film test described above as well as the screen investigations presented earlier (REICHMANN & HELANDER 1974) The screens with high structure mottle give rise to useless images regardless of film (Fig 1 a) while those with low structure mottle produced acceptable results Medichrome film had a slight but definite advantage compared with the 90 second black and white film (Fig 1 b and) The best image was obtained with X omatic screens and Mamoray T3 film However no great difference existed between this film and the Medichrome film when the latter was correctly exposed

Clinical application

Since the image quality of the femur was regarded as acceptable at 120 kV with X omatic screens in conjunction with Medichrome film, this combination was given a preliminary test in clinical examinations Three types of examination were chosen skeleton of the trunk, urography and cholecystography A tube potential of 60 to 80 kV with Siemens Saphir screens and Curix RP film is in routine use today This technique was used as a reference technique, so that all the patients were examined in the same way One or more double exposures were made image pairs were thus produced one image being obtained with the reference technique and the other with the high voltage technique A tube potential of 120 kV was the rule throughout in the high voltage system in the



Fig 5 Chest roentgenogram recorded 150 kV The richness in detail suggests that higher tube potentials may be useful

urography and skeletal examinations In cholecystography various potentials between 80 and 120 kV were tested most recordings were made at 90 kV Chest films were also occasionally obtained at 150 kV as compared with 120 kV for the reference system Forty eight image pairs were obtained from the same number of patients in the skeletal examinations while 17 image pairs were taken one from each patient in the urographies The number of cholecystographic images was 37 in 16 patients The patients were adults and some were aged

The test results were promising (Figs 2—5) The structure of trabecular bone stood out amazingly well even in obese patients with senile osteoporosis (Fig 2) As against the low voltage reference technique no information was lost in the skeletal images However one important condition was the correct exposure of the high voltage films with this exposure incorrect information was lost A small degree of under exposure was especially unfortunate since this produced a false impression of it being adequate The high voltage image was somewhat under exposed in a patient with spinal metastases from mammary carcinoma the vertebral changes might have been overlooked if the under exposure had been unrecognized

The contrast filled renal pelvis, ureters and bladder stood out well in urography (Fig 3) In one patient only 25 per cent of the normal dose of medium could be injected owing to severe urticaria reaction an acceptable film was obtained with the high voltage technique (Fig 3 b) The renal outline was often difficult to follow when high voltage was employed a low voltage technique should probably be used for the demonstration of kidney shape and calcifications before the injection of contrast medium

A gallbladder with an ordinary contrast filling was adequately depicted even at 120 kV Excellent recording appeared always to occur at 90 kV except in those with an extremely low concentration of contrast medium (Fig 4)

The chest films obtained were exceptionally good (Fig 5) possibly even higher voltages may be useful in this type of examination

One general impression gained from the high voltage technique was that several structures could be superimposed without much disturbing effect (Cf the iliac bones and the lumbar vertebra in Fig 2 b)

Discussion

The present investigation indicated that a high voltage technique may be useful to a greater degree than is realized today if noise reduction be undertaken the noise to be attacked is inherent in the film and the intensifying screens The most useful screen film combination of those tested appeared to be Kodak X-omatic Regular screens with Agfa/Gevaert Medichrome film

Medichrome film is a blue colour film that demands special viewing conditions In white light the film tones vary between white and deep blue and the contrast is low However since the noise level is low the low contrast blue image contains information not readily accessible to the unaided eye If the film be inspected through a yellow filter the tones of the film will vary from yellow to green the film thus becoming bi coloured Contrast is markedly increased in this way Still more information may be obtained by means of a red filter the tones of the film then vary from red to black with extremely high contrast

Some insights were gained as to the viewing of high voltage images The yellow filter proved to be of great value for ordinary inspection This could well be done under conventional viewing conditions strong light being usually unnecessary The red filter caused more loss of light and inspection at a distance was then impaired However the red filter could be mounted into the viewer constructed by MATTSSON (1952) Inspection could then usually be carried out without an abnormally strong light source The presence of the yellow filter did not interfere when the films were inspected through the red filter Thus a good technical solution of the filter problem was based on the permanent presence of a yellow

filter in the light box so that all roentgenograms were given the basic increase of contrast afforded details could be inspected more closely with a Mattsson viewer fitted with a red filter It was repeatedly found that conventional black and white roentgenograms could easily be inspected by means of the light box with a yellow light The subjective contrast did not suffer and with adequate exposure the films were not too dark

SUMMARY

A high voltage technique seems to be more useful than is generally believed provided certain precautions are taken A theory on the nature of such precautions is presented and discussed Some clinical applications are described

ZUSAMMENFASSUNG

Die Hochvolt Technik scheint am endbarer als allgemein angenommen zu sein unter der Voraussetzung dass gewisse Vorsichtsmassnahmen ergenommen werden Eine Theorie uber die Art derartiger Vorsichtsmassnahmen wird gegeben und diskutiert Einige klinische Anwendungen werden beschrieben

RÉSUMÉ

Une technique de haute voltage parait plus utile qu on ne le croit generalement condition de prendre certaines precautions Les auteurs presentent et examinent une theorie sur la nature de ces precautions Ils decrivent quelques applications cliniques

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ANGLE DISTORTION IN NARROW BEAM ROTATION RADIOGRAPHY

KJELL ARNE SAMFORS and ULF WELANDER

A panoramic image produced with a rotating narrow beam system is made up of two central projections acting simultaneously. One of these projections has the rotation centre as an imaginary focus and determines the horizontal dimensions of the image, and the other has the tube target as its focus and gives the vertical dimensions; the latter projection furthermore produces blurring in the horizontal plane of the image (WELANDER & NYSTRÖM 1971, 1974, WELANDER 1974). The fact that different projections determine the dimensions in the horizontal and vertical directions results in a disproportionality between the length and height measurements of the image, so that the slope of obliquely positioned details in the object will be depicted incorrectly. The combined effect of different horizontal and vertical dimensions in an image exposed with a rotating narrow beam method may therefore be described as angle distortion.

The distortion in the images obtained with an Orthopantomograph has been analysed experimentally by SCHOPF (1966), LANGLAND (1968), and HEDIN (1971). The geometrical proportions of the image in both horizontal and vertical directions were calculated mathematically by PAATERO... LAMMISALO (1964), but his mathematical expression for the horizontal dimensions of the image is not quite

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correct in so far as the magnitude of the blurring has an effect on the length of a calculated distance in the image The combined distortion due to differing proportionality in the image in the horizontal and vertical directions—angle distortion—does not seem to have been analysed mathematically previously

The mathematical expressions were deduced using the model for narrow beam rotation methods presented by WELANDER (1974)

Angle distortion

In the horizontal plane the length of the image is directly proportional to the ratio of the velocity of the film to the velocity of the beam in the object

$$d_f = \frac{d_o R \omega_f}{r \omega_o}$$

where d_f is the length of the image d_o the length of the object R the radius of the film ω_f the angular velocity of the film r the radius of the object and ω_o the angular velocity of the beam in the object

If the radius of the other object r is given an increment Δr the length of the image will be

$$d_f = \frac{d_o R \omega_f}{(r+\Delta r)\,\omega_o} \qquad (1)$$

From this expression the horizontal dimensions of the image are obtained (Fig 1)

In the vertical plane the height of the exposed image is directly proportional to the ratio of the target film distance to the target object distance

$$h_f = \frac{h_o A}{D}$$

where h_f is the height of the image h_o the height of the object A the target film distance and D the target-object distance

If the radius of the object is given an increment Δr the target-object distance receives the same increment and the height of the image when the radius of the object varies will be

$$h_f = \frac{h_o A}{D \mp \Delta r} \qquad (2$$

From this expression the vertical dimensions of the image are obtained (Fig 1)

FROM THE SECTION FOR MAXILLO FACIAL ROENTGENOLOGY DEPARTMENT OF RADIOLOGY CENTRALLASARETTET S 961 19 BODEN SWEDEN

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A panoramic image produced with a rotating narrow beam system is made up of two central projections acting simultaneously One of these projections has the rotation centre as an imaginary focus, and determines the horizontal dimensions of the image and the other has the tube target as its focus and gives the vertical dimensions the latter projection furthermore produces blurring in the horizontal plane of the image (WELANDER & NYSTROM 1971 1974 WELANDER 1974) The fact that different projections determine the dimensions in the horizontal and vertical directions results in a disproportionality between the length and height measurements of the image so that the slope of obliquely positioned details in the object will be depicted incorrectly The combined effect of different horizontal and vertical dimensions in an image exposed with a rotating narrow beam method may therefore be described as angle distortion

The distortion in the images obtained with an Orthopantomograph has been analysed experimentally by SCHOPF (1966) LANGLAND (1968) and HEDIN (1971) The geometrical proportions of the image in both horizontal and vertical directions were calculated mathematically by TAMMISALO (1964) but his mathematical expression for the horizontal dimensions of the image is not quite

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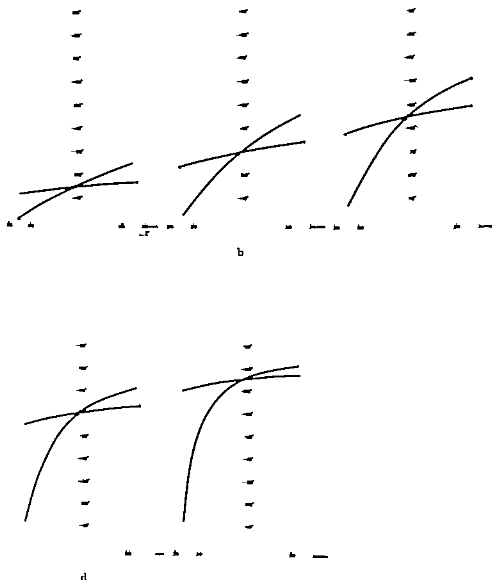


Fig The angle of inclination α of structural detail in relation to the horizontal plane in the image as function of an increment to the radius of the object Th t ons re lid for the nterior rotation centre = 78 mm (——■) and mean alue t d eff tr projection radius in the lateral rotation centre = 96 mm (●———●) in the Orthopan tomograph 3 I the continuous transit on between the rota on cen res re continually in the interval bet een the functions Th angle of nclination for the real lope of the tructural detail in the object is 1 in ( ) 30 in (b) 45 in ( ) 60 in (d) and 7 in ( ) Tl ngles of the object re correctly depicted in th sharply depicted object plane ngle distortion occurs outside this plane





b



Fig 3 Effect of angle distortion in roentgen images produced with narrow rotating beam) The position of the object agrees satisfactorily with th sharply depicted object plane b) Th object is positioned in front of the sharply depicted object plane The angle mad by structural detail with the horizontal plane is increased) The object is positioned behind the sharply depicted object plane The angle made by structural detail is reduced

Equation (3) or the simplified expression equation (4) may be used to calculate the combined effect of the horizontal and vertical dimensions of the image —the angle distortion—in rotating narrow beam methods For object parts with slopes of 15 30 45 60 and 75 in relation to the horizontal plane $\frac{h_0}{d_0}$ is 0 2679 0 5774 1 1 732 and 3 732 respectively With the values for object radii and for the target film and target object distances that apply in the Orthopantomograph 3 the functions illustrated in Fig 2 will be obtained

Discussion

The functions (Fig 2) illustrate the angle distortion of an object without thickness, when it is displaced in relation to the centre of the object plane de

picted without blurring by a rotating narrow beam method. The functions also illustrate the effect of angle distortion in an object with thickness.

The magnification factor at the centre of the object plane depicted without blurring is the same in both horizontal and vertical directions. There is thus no distortion at the centre of this plane but the image is magnified; the magnification factor is the same irrespective of the object radius. However, even small increments to the object radius cause angle distortion to arise in the image. The distortion is greatest when the radii are small and is most marked for structural details in the object that form a large angle with the horizontal plane, for example obliquely positioned non-erupted teeth.

The angle distortion arising in connection with narrow beam rotation methods is such that the positioning of the object in the equipment may be regarded as critical. The slope of the teeth in the image is influenced by their position in relation to that part of the object which is depicted without blurring; a tooth lying in front of the centre of the sharply depicted object plane will have in the image a seemingly increased angle in relation to the horizontal plane, while for a tooth lying behind the sharply depicted plane the angle will appear reduced (Fig. 3). It is obvious that since the teeth slope not only in a mesial distal but also in a buccal lingual direction, the angle distortion in the image may be considerable.

In panoramic views of the teeth and jaws produced with a narrow beam rotation method the distortion in areas outside the centre of the sharply depicted object plane is such that the true slope of any particular detail is hard to assess correctly.

SUMMARY

The distortion of a panorama roentgen image of the teeth and jaws exposed with rotating narrow beam depends on differing proportionality in the image in the horizontal and vertical planes. This distortion may be defined as angle distortion and has the effect that obliquely positioned structural details in the object will be depicted with a false angulation in the image. The angle distortion has been calculated mathematically. Outside the sharply depicted object plane angle distortion may be considerable; it is greatest when the projection radii are small and most marked for structural details in the object that form a large angle with the horizontal plane.

ZUSAMMENFASSUNG

Die Distorsion eines Panorama Röntgenbildes der Zähne und Kiefer exponiert mit einem rotierenden schmalen Strahl hängt von der unterschiedlichen Proportionalität der horizontalen und vertikalen Ebenen im Bild ab. Diese Distorsion lässt sich als Winkeldistorsion definieren und hat zur Folge, dass die schräg gestellten strukturellen Einzelheiten des

Review of the literature

In anatomic literature the intraorbital veins are described in detail (SESEMANN 1869, GURWITSCH 1883, HENRY 1959). This information is not directly applicable to orbital phlebography, however, as the veins usually demonstrated at phlebography cannot be anatomically distinguished from veins that are not significant phlebographically. The anatomic presentations have often been arranged with the surgical approach to the orbit in mind and comparison with the phlebographic appearance is difficult for this reason also. Angiography of anatomic specimens of the orbits have been made by SALAMON et coll. (1972) who described briefly three main ophthalmic veins (one superior, one middle and one inferior) connected by collaterals, but gave no information about the frequency of the different veins or their variations.

In the literature on orbital phlebography, interest has been focused almost exclusively on the superior ophthalmic vein; information concerning other intraorbital veins is scanty. BOUDET (1953, 1955) and ARON ROSA et coll. (1967) stated that the inferior ophthalmic vein was narrow and that it filled rarely and then incompletely through small vertical collaterals. HANAFEE (1972) declared that this vein was only inconsistently filled and was not closely related to vital structures. A narrow inferior ophthalmic vein was observed by LOMBARDI & PASSERINI (1968) in 13 out of 27 normal cases. More detailed results were reported by VIGNAUD (1970) who in a material of 20 patients managed to fill the inferior ophthalmic vein in 19 cases, collateral veins in 19, the lacrimal vein in 12, and veins of the second order in 11 cases. No further analysis of the findings was given.

Present investigation

A detailed description of the technique used has been given previously (BRISMAR 1974 a) and is therefore not repeated here.

The analysis of the small orbital veins is based on the same phlebographic material of 60 patients used in previous reports on the phlebographic technique and on the anatomy of the superior ophthalmic vein (BRISMAR 1974 a, b). The material suitable for a detailed analysis of the intraorbital venous anatomy consisted of 57 orbits arranged into two groups: 38 orbits in 32 patients with normal cavernous sinuses as well (group N), and 19 orbits in 10 patients with an intra- or parasellar expansive lesion but with no obstruction of the flow of contrast medium through the cavernous sinuses (group S).

Results

Nomenclature

It was necessary to supplement the existing nomenclature as several of the intraorbital veins presented in this report have not previously been identified at

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ORBITAL PHLEBOGRAPHY

III Topography of intraorbital veins

JAN BRISMAR

The value of orbital phlebography in cases with unilateral proptosis is well established (e g LOMBARDI & PASSERINI 1969 LLOYD 1970 HANAFEE 1972 HAYE et coll 1970 BOUDET 1955 ARON ROSA et coll 1966) The diagnosis of a lesion is based mainly on changes in the superior ophthalmic vein Displacement of this vessel will indicate not only the presence of an expansive lesion but also its location (e g SCHOBER & BENDER 1968 HAYE et coll 1970) In cases of major displacement of this vein few diagnostic problems exist but when there is only a small difference between the location of the vein in the two orbits the diagnosis of tumor is hazardous because a significant asymmetry between the two sides may be a normal condition (BRISMAR 1974 b) Since even small orbital veins are almost constantly demonstrated by the use of the present author's technique (BRISMAR 1974 a) it seemed reasonable to aim at a more certain diagnosis by also analyzing possible displacements of these veins A prerequisite then is a deeper knowledge of the normal phlebographic appearance of these veins and their variations than is available at present In the past this aspect has not gained much attention in reports on orbital phlebography

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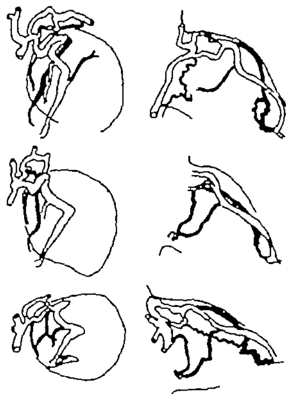


Fig. 2. The medial ophthalmic vein. Tracings in top and lateral views of three orbits. Bottom: Atypical medial vein.

In addition to the two tributaries (BRISMAR 1974 b) to the superior ophthalmic vein and to the posterior parts of the ophthalmic veins three types of connections between the intra and extraorbital veins were identified. They have been designated anterior, lateral and inferior extraorbital anastomosing veins.

Comparison between groups N and S. The frequency of filling of the different veins was analyzed separately for the groups N and S without any significant difference between the two groups being found (Table 1), nor was there any interindividual difference in the appearance of the superior ophthalmic vein between similar groups (BRISMAR 1974 b). These groups will therefore be discussed as one entity.

Superior ophthalmic vein. This vein can always be demonstrated in normal cases with an adequate phlebographic technique (Fig. 1). Its appearance has been described earlier (BRISMAR 1974 b) and will not be discussed further in this report.

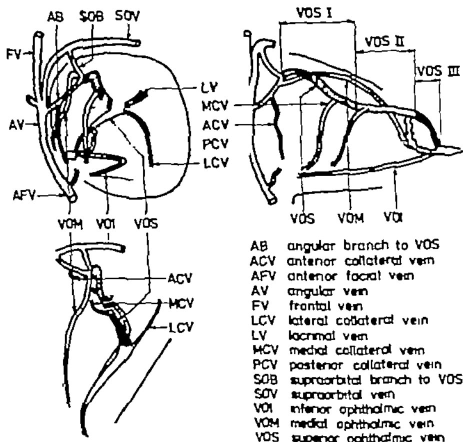


Fig 1 Suggested nomenclature of the intraorbital veins in p lateral and axial views

phlebography Intraorbital collaterals have been treated largely as an entity (BOUDET 1953 OFFRET & ARON RO A 1965 HAYE et coll 1970) although sometimes separated into medial and lateral collateral veins (LOMBARDI & PASSERINI 1968) In the present material four collateral veins were frequently found all directly connected to the superior ophthalmic vein and sometimes also to the inferior ophthalmic vein They all had a course eventually from the floor to the roof of the orbit These veins were named the anterior posterior medial and lateral collateral veins with respect to their positions in the orbit The designation medial ophthalmic vein was reserved for a vein running from the anterior part of the orbit backwards to the cavernous sinus A schematic presentation of the phlebographic appearance of the intraorbital veins and the suggested nomenclature is given in Fig 1



Fig. 3. Bilateral medial ophthalmic veins (→) largely superimposed on the superior ophthalmic veins in the lateral view (b).

most cases exceeded 1.0 mm, although in 13 cases it was less than 0.8 mm. GURWITSCH reported that in one third of his cases, no true inferior ophthalmic vein could be identified, but that the function of the vein was taken over by a medial collateral vein.

The inferior ophthalmic vein usually (20 orbits) originated at the anterior medial part of the orbital floor from a venous rete anatomically described by SESEMAN and GURWITSCH. This rete is formed by the anterior collateral vein and in most cases also by the medial collateral vein; it may be connected with the lateral collateral vein, and most often sends a thin anastomosis across the inferior orbital ridge to the anterior facial vein (Fig. 1). From this rete the inferior ophthalmic vein runs in a medially open curve, in most cases close to the orbital floor situated on the surface of the inferior rectus muscle (GURWITSCH) and leaves the orbit through the inferior part of the superior orbital fissure below anulus tendineus communis. In three of the cases where the inferior ophthalmic vein was observed to originate in this rete, it was also connected with the medial collateral vein, and in one case with the lateral collateral vein. In 9 orbits the

Tabl 1

Intraorbital veins in the groups N (normal orbit and no venous stasis) and S (normal orbit possible proximal intra- or parasellar disorder) VOS = superior VOM = medial and VOI = inferior ophthalmic veins ACV = anterior MCV = medial LCV = lateral and PCV = posterior collateral veins LV = lacrimal vein

	N n = 38		S = 19		N+S = 57	
	n					
VOS	38	100	19	100	57	100
VOM	18	47	4	21	22	39
VOI	26	68	11	58	37	65
ACV	35	92	17	89	5	91
MCV	36	95	19	100	55	97
LCV	30	79	11	58	41	7[illegible]
PCV	8	21	3	16	11	19
LV	28	74	1	79	43	7

Medial ophthalmic vein A medial orbital vein with a characteristic course was found in 22 out of 57 orbits (39 per cent) (Figs 2 3 4) This vein probably corresponds to a vein found by GURWITSCH in 3 of 42 orbits but has not previously been described at phlebography It originates in either the angular tributary to the superior ophthalmic vein or in its anterior segment It follows the orbital roof backwards close to the medial orbital wall and descends in the posterior part of the orbit to enter the cavernous sinus below the superior ophthalmic vein

The medial ophthalmic vein in most cases had a diameter of 1 to 2 mm and was most easily recognized in an axial view In the a p view it may be obscured by the anterior or medial collateral veins in the lateral view by the superior ophthalmic vein In the posterior part of the orbit where the vein passes down on the medial side of the muscular cone it seems to be compressed from side to side and appears very narrow in the a p view but broad and often irregular in the lateral view

In two orbits another medial vein was seen, with a different course It ran straight from the angular tributary backwards to the cavernous sinus along the medial orbital wall In one of these cases the medial ophthalmic vein could also be identified (Fig 2 bottom)

Inferior ophthalmic vein An inferior ophthalmic vein was observed in 37 out of 57 orbits (65 per cent) In t additional cases only a short posterior part of the vein could be identified The diameter of the inferior ophthalmic vein in

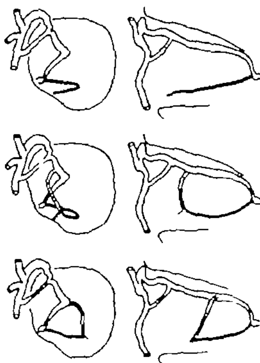


Fig 5 Inf rior ophthalmic vein without connection to the collateral veins (16/57 orbits 45) (top) or connected t the medial (12/57 orbits 32) (middle) or t the lateral (8/57 orbits 22) (bottom) collateral veins

inferior ophthalmic vein originated from the medial and in 7 from the lateral collateral vein (Fig 5)

An anastomosis between the inferior ophthalmic vein and the pterygoid plexus through the inferior orbital fissure was found by GURWITSCH in 43 per cent of his material This anastomosis occurred in 14 cases in the present material In one of these cases no connection was observed between the inferior ophthalmic vein and the collateral veins or the rete In one case (not included in the material of 57 orbits) this communication was wide and constituted a direct continuation of the inferior ophthalmic vein (Fig 4) One similar case was illustrated in the report of SEBEMAN

Double inferior ophthalmic veins were present in 7 orbits One vein had the normal course close to the orbital floor the other was localized higher up in the orbit but otherwise had a similar course (Fig 6) This second vein probably corresponds to the veine ophtalmique moyenne mentioned by HENRY (1959)

Anterior collateral vein A slender vein passing along the anterior part of the medial orbital wall from the angular branch of the superior ophthalmic vein to the rete in the anterior medial part of the orbital floor was demonstrated in 52

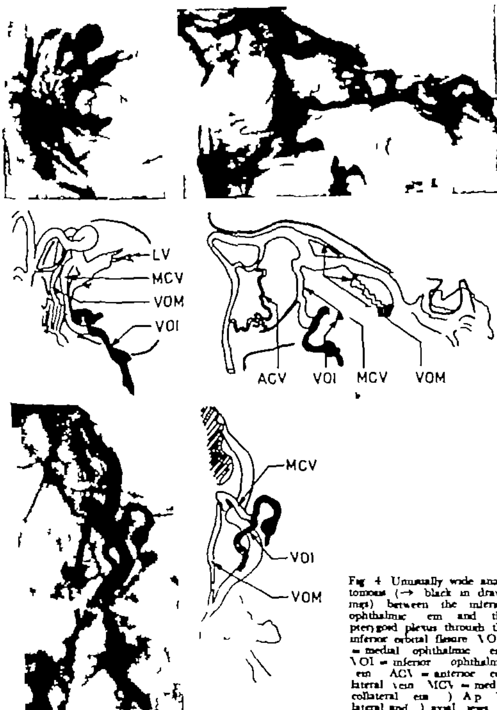
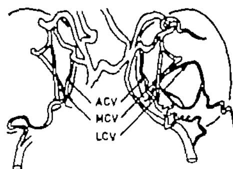


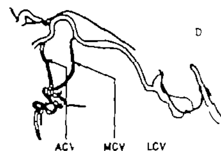
Fig. 4. Unusually wide anastomosis (→ black in drawings) between the inferior ophthalmic vein and the pterygoid plexus through the inferior orbital fissure. VOM = medial ophthalmic vein, VOI = inferior ophthalmic vein, ACV = anterior collateral vein, MCV = medial collateral vein.) A.p., b) lateral and) axial views.

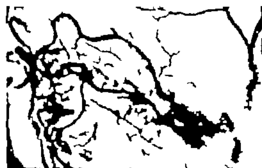






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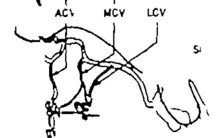


Fig 7 L rge ant rior collateral eins on the right side continuing directly dow through the rete t the anterior f cial ein Lateral branch to the lateral collateral vein from extraorbital facial eins on the left side (→)) A p b) straight lateral nd c) oblique lateral re s

Lateral collateral v in The lateral collateral vein was demonstrated in 41 out of 57 orbits (72 per cent) in 7 only for a short distance In the remaining 34 orbits the vein could be followed down to the anterior lateral part of the orbital floor It ran in a wide curve open medially and inferiorly passing on the lateral side of the muscular cone, and joined the middle segment of the sup rior ophthalmic vein





Fig 6 Bilateral double inferior ophthalmic veins (→)) A p and b) straight lateral ves) Drawing from oblique lateral ve Left full drawn right interrupted line

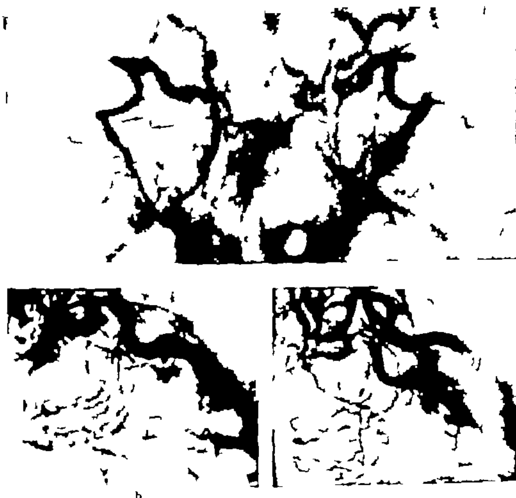
of 57 orbits (91 per cent) (Figs 4 7 8) The vein often anastomosed with the angular vein through narrow channels In some cases the anterior collateral vein continued directly through the rete over the inferior orbital ridge to anastomose with the anterior facial vein (Fig 7) The diameter of the anterior collateral vein was most often about 0 6 mm but could be considerably wider (Fig 7)

Medial collateral vein The medial collateral vein was demonstrated in 55 out of 57 orbits (97 per cent) in 50 completely in 5 only fragmentarily This vein (already described by GURWITSCH) after having passed superiorly and slightly backwards on the medial side of the muscular cone bends laterally to join the superior ophthalmic vein under the superior rectus muscle

The vein was demonstrated down to the rete in 49 cases In 13 of these it also gave off branches laterally below the muscular cone to communicate with the inferior ophthalmic vein In one case it was connected only to the inferior ophthalmic vein A schematic presentation of the different types of ramification of the medial collateral vein is presented in Fig 9

The medial collateral vein was doubled in five orbits In three cases the branches from the rete and from the inferior ophthalmic vein were connected separately to the superior ophthalmic vein while in two cases paired branches left the rete (Fig 10)

The medial collateral vein is usually the largest of the collateral veins and its diameter may equal that of the superior ophthalmic vein In cases of occlusion of the latter the medial coll[illegible] vein must not be mistaken for a patent superior ophthalmic vein [illegible]



b

F g 10 Right double medial collateral eins do to the ret (→)) A p b) straight lateral and) oblique lateral ew

smooth curve directly down to the rete (Fig 11 bottom) Nothing suggests that this course was caused by an intraorbital disorder A schematic presentation of the different types of ramifications of the lateral collateral vein is given in Fig 11

Posterior collateral vein A vein originating from the posterior end of the midsegment of the superior ophthalmic vein was present in 11 out of 57 orbits (19 per cent) Thus the posterior collateral vein, in most cases turned forwards laterally and downwards probably to pass around the muscular cone and then backwards to the cavernous sinus (Figs 1 12) In the lateral view this vein like

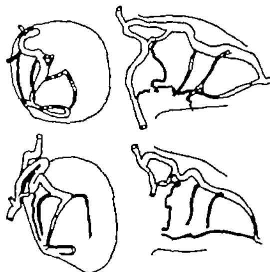


Fig 8 Anterior collateral veins (filled) in two orbits p and lateral dra ings

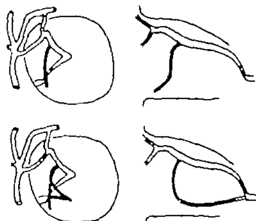


Fig 9 Medial collateral vein running directly from the rete to the superior ophthalmic vein (top) (36/50 orbit 7 %) connected to the inferior ophthalmic vein by lateral branch (14/50 orbits 28 %) (bottom)

The lateral collateral vein communicated with the inferior ophthalmic vein in 11 orbits In four of these it also received a lateral branch and in one case a branch from the rete No connection between the lateral collateral vein and the inferior ophthalmic vein could be observed in 23 orbits The lateral collateral vein received a branch from the rete in 5 of these cases and in 2 also a lateral branch

In the total material (60 patients orbital disorders and incomplete examinations included) the lateral collateral vein had a different course in three orbit The vein did not run to the frontal latero basal corner of the orbit but in a



Fig. 12. Anterior (ACV), medial (MCV), lateral (LCV) and posterior (PCV) collateral veins. a) A-p, b) lateral and c) axial view.

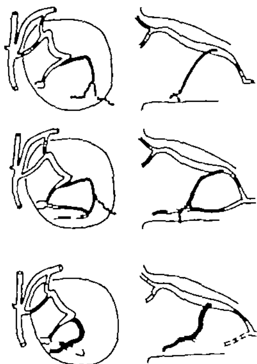


Fig 11 Lateral collateral vein running to the inferior lateral anterior part of the orbit possibly together with branches from the rete or from lateral extra orbital veins but not connected to the inferior ophthalmic vein (23/34 orbits 68) (top) Communicating with the inferior ophthalmic vein (11/34 orbits 32) (middle) Different course directly down toward the rete (in three cases not included in the normal material) (bottom)

the medial ophthalmic vein had an irregular outline In the total material of 120 orbits it occurred in 19 orbits bilaterally in 7 patients (14 orbits) In three of the remaining five patients with a unilateral posterior collateral vein a medial ophthalmic vein was present on the other side

Lacrimal vein The lacrimal vein could be identified in 48 out of 57 orbits (7? per cent) in most cases only its posterior part It joined the midsegment of the superior ophthalmic vein as one or several branches (Figs 1 4) but was in several cases connected instead to the posterior part of the lateral collateral vein These results agree with those of GURWITSCH The sphenoparietal sinus (BRISMAR 1974 c) is easily mistaken for the lacrimal vein in an a p view In the axial view however separation of the two veins is easy

Anastomoses between the extra and intraorbital veins

Besides the supraorbital and angular tributaries to the superior ophthalmic veins and the connections between the posterior parts of the ophthalmic veins and the cavernous sinuses several communications between the intra and extra

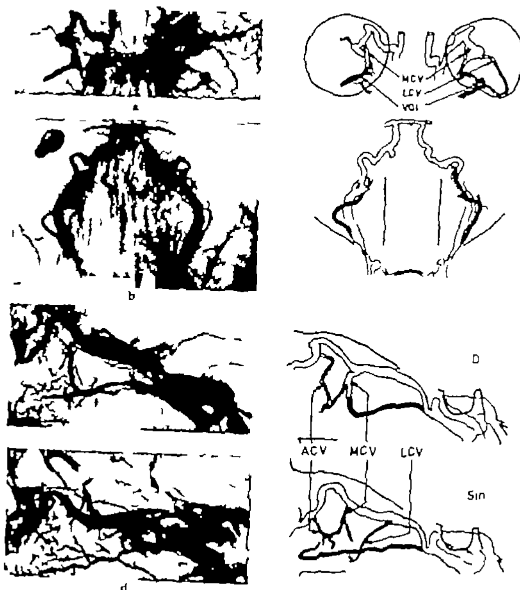


Fig 13 Inferior ophthalmic vein (VOI) Right side The vein originates from the medial collateral vein (MCV) which its other branch is connected to the rete Left side The vein runs normal course from the rete but also communicates with the lateral collateral vein (LCV) Anterior collateral veins (ACV) bilaterally) A p b) axial c) d) lateral view

makes it easy to confuse with a displaced superior ophthalmic vein in cases with occlusion of the latter

Double inferior ophthalmic veins occurred in about ten per cent of the orbits one vein located close to the orbital floor and one with a similar course but

Table 2

Connections between the intra- and extraorbital veins in the groups N (normal orbit and cavernous sinuses) and S (normal orbit, possible or proved intra- or parasellar disorder). AEA = anterior, LEA = lateral and IEA = inferior extraorbital anastomosis

	N = 38		S = 19		N + S = 57	
			n			
AEA	18	47	8	42	6	46
LEA	3	8	7	37	10	18
IEA	9	24	5	26	14	2

orbital veins exist (SESEMAN, GURWITSCH). In the present material such additional communications existed in 35 out of 57 orbits (Table 2).

Anterior extraorbital anastomosing vein. A connection between the rete and the anterior facial vein was found in 26 out of 57 orbits (Figs 2, 4, 7). As the routine phlebographic procedure includes compression over the place where this connection enters the anterior facial vein, the actual incidence is probably much higher.

Lateral extraorbital anastomosing vein. Connections between the intra- and extraorbital veins may also be located near the lower lateral part of the orbital wall through the lateral collateral vein (Fig. 7). This type of communication occurred in 10 orbits out of 57.

Inferior extraorbital anastomosing vein. Connections from the inferior ophthalmic vein to the pterygoid plexus through the inferior orbital fissure (Fig. 4) existed in 14 orbits out of 57.

Discussion

The technique used in this investigation and previously described in detail (BRISMAR 1974 a) permits a demonstration of the intraorbital veins. These veins, though subject to variations, have a relatively constant arrangement. In addition to the two well known veins, the superior and inferior ophthalmic veins connecting the anterior part of the orbit with the cavernous sinus, an additional ophthalmic vein has been identified in a relatively large number of cases. This vein, designated the medial ophthalmic vein, is often fairly wide. It is of importance in the phlebographic diagnosis of intraorbital disorders as its course

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situated higher up in the orbit A single inferior ophthalmic vein may be located as high up in the orbit as the additional vein Knowledge of this variation is important in order to avoid the diagnosis of an inferiorly situated intraorbital expansive lesion in such cases It was possible to identify four collateral veins, i e veins with an essentially craniocaudal course interconnecting the superior ophthalmic vein with veins at the orbital floor It was also possible to systematize variations in their appearance The medial and lateral collateral veins due to their location on each side of the muscular cone may prove important in the localization of intraorbital expanding lesions The anterior collateral vein will be affected by disorders in the antero-medial part of the orbit

The posterior collateral vein was identified in only one fifth of the cases Its somewhat bizarre appearance especially in the lateral view may tempt an examiner to regard it as a pathologic collateral vein indicating an obstruction of the posterior part of the superior ophthalmic vein This risk is not insignificant, particularly because in normal cases the diameter of the posterior segment of the superior ophthalmic vein may be greatly reduced

SUMMARY

The phlebographic anatomy of the orbital veins is described on the basis of material of 57 normal orbits In addition to the superior and inferior ophthalmic veins a medial ophthalmic vein and four different collateral veins were identified Diagnostic implications of detailed knowledge of the anatomy of the intraorbital veins are stressed

ZUSAMMENFASSUNG

Die phlebographische Anatomie der Orbitalvenen wird an hand eines Materials von 57 normalen Augenhohlen untersucht Zusätzlich zu den oberen und unteren Augenvenen werden vier verschiedene Kollateralvenen identifiziert Die diagnostischen Folgerungen der detaillierten Kenntnis der Anatomie der intraorbitalen Venen werden hervorgehoben

RÉSUMÉ

Description de l anatomie phlebographique des veines orbitaires d apres une serie de 57 orbites normales En plus des veines ophtalmiques superieure et inferieure l auteur identifie une veine ophtalmique interne et quatre veines collaterales differentes Il souligne les consequences diagnostiques d une connaissance detaillee de l anatomie des veines intra orbitaires

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the type of the defect and on the existence of associated malformations and their sequelae such as interhemispheric cysts and hydrocephalus (cf PROBST 1973) As the malformations of the brain mainly involve the structures in the median and paramedian region, or more distinctly speaking the third ventricle, lateral ventricles and medial parts of the hemispheric surfaces vascular abnormalities of diagnostic significance are likely to be found in vessels closely related to these structures The relation between the pericallosal artery and the corresponding part of the third ventricle was analyzed in order to assess to what extent the course of the artery is affected by widening of the third ventricle

Previous investigations MAURER described some abnormal features in the course of the pericallosal artery but he did not observe any change of its anterior part ZELLWEGER had examined 5 patients, and in 3 of them he stated that the pericallosal artery was absent his figure 4 however shows clearly this artery and the distinguishing feature in its course namely the steep rise of its first segment and the absence of the typical anterior part, i e the part curving around the callosal knee This angiographic sign was later described by SHELDON & PEYMAN and subsequently confirmed by most of the later authors ZELLWEGER, in particular as well as FISCHER, also stressed the abnormal course and distribution of the callosomarginal artery and its branches FISCHER discussed the difficulties arising when several irregular arteries running in the interhemispheric fissure are to be classified SHELDON & PEYMAN among others also described changes in the shape and position of the internal cerebral veins, which were found to be elevated MORRIS mentioned separation of the internal cerebral veins in cases with dilatation of the third ventricle

Several authors have considered that the axis of the middle cerebral artery group is raised in defects of the corpus callosum (ZELLWEGER HOLMAN & MAC CARTY CLAUS & HEIDRICH)

Material The morphology and encephalographic appearances of defects of the corpus callosum based on a material of 50 cases have been published previously (PROBST 1973) Carotid angiography was performed in 16 of these cases and the vascular abnormalities encountered are correlated to the adjacent anatomic structures in the present report

Results

The pericallosal artery

The pericallosal artery arises from the anterior cerebral artery at the anterior communicating artery and is normally divided into an inferior anterior and

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ANGIOGRAPHIC FEATURES IN CONGENITAL DEFECTS OF THE CORPUS CALLOSUM

F P PROBST

Carotid angiography is being used with increasing frequency as the first radiologic procedure in mental disturbances or epileptic conditions The angiographic signs of defects of the corpus callosum are therefore commanding more attention especially since it has become obvious that this condition may be diagnosed by angiography

Since MAURER (1940) described the first case of agenesis of the corpus callosum examined by carotid angiography some additional cases have been reported (ZELLWEGER 1952 SHELDON & PEYMAN 1953 VAN EPPS 1953 FISCHER 1959 HOLMAN & MACCARTY 1959 CLAUS & HEIDRICH 1960 KOZLOWSKI & ALAPIN 1961 KVICALA 1961 MORRIS 1962 NOBLER et coll 1963 ZINGESSER et coll 1964 LARSEN 1966 BULL 1967 HANDA et coll 1969 SZDZUY et coll 1972) However the total number of cases up to 1972 did not exceed 25 Additional reporting on cases examined by carotid angiography would seem to be desirable if more detailed knowledge about the vascular abnormalities is to be gained This would increase the accuracy of the angiographic diagnosis of this malformation and would be especially valuable since the brain abnormalities in agenesis of the corpus callosum vary within rather wide limits depending on

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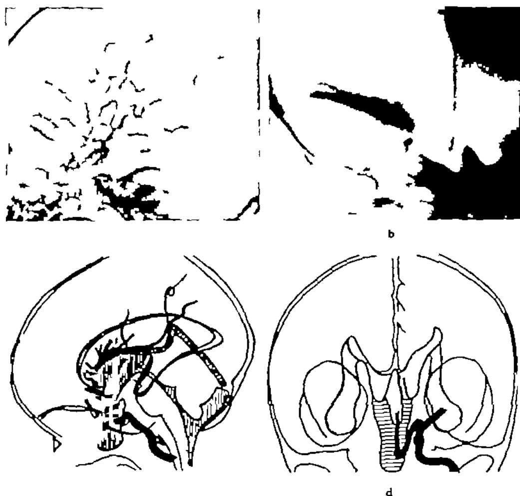
Fig 2 Complet callosal defect Carotid angiography venous phase corresponding encephalographic view th composite drawing The nternal cerebral ei displaced laterally parallel to the inferior sagittal sinus ppears shortened in the lateral view because its posterior segment (→) runs mainly in medial direction to join its mat and the straight sinus Vena magna absent Venous ngle located unusually high nd posteriorly (⟶)

b

d



Fig 1 Complete callosal defect Righ carotid angi graph and encephalography t ge of 13 months with composite drawing The pericallosal artery follow the dilated third entricle (d) and deviates towards the sp ila eral side) This part of the artery runs in th depth of the cistern of the lateral callosal substitute Its branches (→) curv around an enrolled marginal convolution (←) Enlargement of the posterior fossa due to Dand —Walker cyst causing elev tion of the transverse sinuses ( ) The confluens sinuum is located unusually high



F g 4 Complete callosal defect associated w th anterobasal encephalocystocele h per lorism and left lip nd palat Carotid angiography nd encephalography with composite draw ngs The pericallosal rtery is tilted posteriorl running long the w ll of the cystocele and j wes the enous anel t the same lev l A corpus callosum cannot reasonably exist bet een them The internal cerebral ens losely adjacent to the midline on the roof of the th rd entricle which is not elev ted and lacks the usual sin oid shape

so far forward and inferiorly that the ascending part did not pass upward anteriorly but posteriorly instead (Fig 4)

The knee The transition between the inferior and superior segments of the pericallosal artery was also abnormal in all cases The knee had the appearance of a right angled or obtuse angled curve (8 cases) or was more or less acute angled (4 cases) or deformed in other ways (4 cases) It seemed to be situated

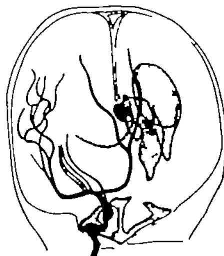


Fig 3 Complete callosal defect associated with avascular expanding process on right side Composite drawing of angiographic and encephalographic p ews The common trunk and internal cerebral ein re pushed over to the left and the thalamostriate ein is elongated The arteries to the basal ganglia are stretched and rched laterally

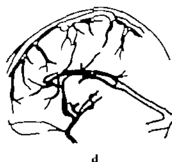
sup rior part (LINDGREN 1954) In cases with agenesis of the corpus callosum the anterior part normally curving around the genu is absent The inferior part has a more ascending course and forms with the sup rior part a more or less marked knee

The inferior (ascending) part A common stem with bihemispheric division was present in 3 of the 16 cases (Figs 3 6 10) In two of these three ca es (cf Fig 6) both callosomarginal arteries arose symmetrically from the pericallosal artery at the origin of the anterior communicating artery and in the third asymmetrically *one of the latter originating from the middle part of the common* stem (Fig 10) In two cases the common stem ascended fairly steeply and The stem lay exactly in the midline in two cases and on the left side in the interhemispheric cyst

The stem lay exactly in the midline in two cases and on the left side in the third After the bifurcation the branches radiated out symmetrically on the medial surfaces of the hemispheres.

In the other cases double pericallosal arteries were present from their origin In one the left artery was hypoplastic The course of these arteries was more or less abnormal As in the cases with a common stem all arteries except two ascended steeply taking as a rule the shortest path up to the genu The left peri callosal artery had an S shaped curvature in one instance and in another with a partial callosal defect the anterior callosal rudiment was distinctly outlined by the artery (Fig 11) In one case the origin of the pericallosal artery was located





F g f Comple callosal defect Angiography half axial iew and compo it drawing of lateral iews) Common runk b) The negativ image sign and displaced essels in th pericallosal cistern (→)) Ipsilateral displace ment f the deep enous system d) The topographical relationship betw een arteries nd eins

The normal vascular appearance in the films when the pericallosal cistern is projected axially and the small arteries within it thus are superimposed on one another has been named the moustache sign (HUANG 1964) the arteries in the cistern are in such a view located almost horizontally and meet in the midline When a callosal defect is present they are displaced laterally and directed more or less vertically (Fig 6)

LILIEQUIST (1967) has mentioned that a negative image of the lateral ven tricles is ometimes observed in the late arterial and capillary phases In two cases (cf Fig 6 b) in this material this negative image had the appearance charac teri tic of callosal defects

Relation of the pericallosal artery to the third ventricle By superimposing the angiographic lateral view on the corresponding encephalographic view it was



Fig 5 Complete callosal defect) Carotid angiography b) Composite drawing f la eral angiographic and encephalographic views Deformity of the pericallosal arteries ( ) indicating callosal defect Absence of the normal curv round genu corporis callosi Superior parts t the same level as the elev ted middle segments of the internal cerebral eins Both are situated lower level than the most dorsally expanding part of the interhemispheric cyst and are di placed towards the ipsilateral side

closer to the base than usual in 3 cases and at a higher level in another 4 cases One case had no distinct knee (Fig 4)

The superior part and its branches This part of the artery occupied a higher level than usual in relation to the base in 3 instances (Figs 1 c 2 e 10 a and had a lower position in 3 others (Figs 4 a 8 13 b c) In a few cases it loped abruptly posteriorly and inferiorly from a knee situated at a high level (Fig 10) Serpiginous lateral curves of the artery obviously exceeding the normal range were observed in 8 cases (Figs 1 5 6 10—13) These appearances seem to be characteristic (Fig 12)

This deformity arises when the pericallosal artery or its branches penetrates deeply into the fissure between a lateral callosal substitute and the marginal convolution (cf Fig 28 in PROBST 1973) On the way out towards the medial surface of the hemisphere the vessels have to course around the marginal con volution with the result that there arise one or several paramedially ituated arterial segments concave upwards in the a p views This deformity thus requires for its development the existence of cisterns close to the lateral callosal substitute and infolded cingulate gyri in other words conditions that are specific to the callosal defects it may therefore be considered pathognomonic

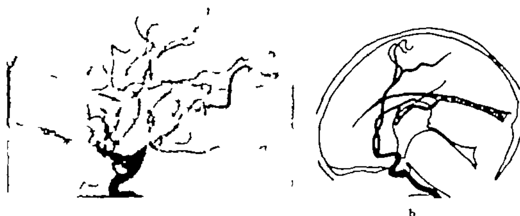


Fig 9 Complete callosal defect) Carotid angiography b) Compound drawing of lateral angiographic and encephalographic views The pericallosal artery (→) is completely unrelated the third ventricle Internal cerebral vein and great vein of Galen flattened as the splenium round which they normally curve is absent

always situated at a higher than normal level, sometimes at roughly the same level as the horizontal part of the pericallosal artery (Figs 1 e, 4 c, 5 b) and deformed in a more irregular fashion in some cases (Figs 5 b 10 b) The venous angle occasionally had a relatively high and occipital position

The subependymal tributaries The medial veins of the body and trigone were located laterally in all cases, reflecting separation of the lateral ventricles The thalamostriate vein caudate veins and the lateral veins of the body and trigone also indicated the shape and lateral extension of the lateral ventricles Evident septum veins were absent in cases with a complete callosal defect but sometimes occurred when the defect was partial in other words if an anterior callosal rudiment and a septum pellucidum were present In one case the paramedian course of the septum vein reflected the separation of the anterior horns due to a cavity of the septum pellucidum (Fig 11 c)

The great vein of Galen was absent in one case (Fig 2 a b) In most of the other cases the normal wide curve was absent (Figs 7 8 9 13) the vein being sharply angulated with a kinked appearance (Fig 5 b) or running into the straight sinus after coursing more or less parallel to the inferior sagittal sinus (Fig 6 d) It emerged into the straight sinus more posteriorly in one case, and in 2 cases more anteriorly than normally



Fig 7 Partial callosal defect Composite dra ing of ngiographic and encephalographic lateral ies Ver tical hatching = entricles terior black crescentic figure = cistern long anterior callosal rudiment pos terior black cre centic area probably small ca ity of the septum pellucidum th dotted area between these represents the terior callosal rudiment Lo origin of the callo omarginal artery t the base of th peri callosal rtery which runs bnormally far front of the anterior surface of the callosal rudiment The knee is unrelated to the callosal rudiment I ternal cerebral ein delimits roof of third entricle situated t nor mal lev l Vena magna has more straight course than normally Inferior sagittal sinu is located unusually low and forms an acut angle w th the internal cerebral ein

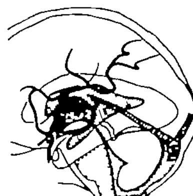


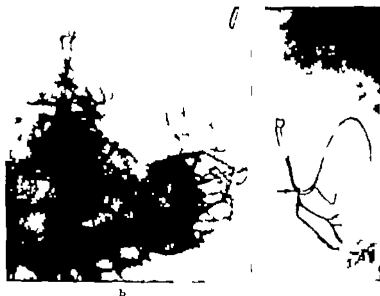
Fig 8 Complete callosal defect Composite drawing of angiographic and encephalographi lateral vie Anterior cerebral rtery ri es steeply Its superior part descends to abnormally lo lev l nd pproaches the lev l of the roof of the third entricle and ternal cerebral ein The latter is psilaterally displaced and lies t abou the same level as the inferior sagittal sinus

found that the ascending part of the p ricallosal artery in 6 cases ran clo e to the lamina terminalis and to that part of the respective midline cyst adjoining it uperiorly (Figs 1 c—e 4 10 f) In 5 of them the first part of the artery had been influenced by the expanding midline cyst and had either been pushed forwards (Fig 4) or had b-come elongated and sloped forward as in the others (Fig 10 a) In the remaining cases the first part was not related to the lamina terminalis but ran instead at varying distances in front of it (Fig 9 b)

The internal cerebral vein and its tributaries the great ein of Gal n

The internal cerebral vein lay close to the midline in 4 cases and about 1 cm to the ip ilateral side in 11 cases (Figs 2 a 6 c 11 c) In one cas- it was dis placed to the contralateral s de owing to the presence of an expanding process (Fig 3) The d-ep cerebral veins in general often had an abnormal appearance being either shorter or flatter than usual (Figs 2 b 6 d 9 b) They were





b

Fig 11 Partial callosal defect Carotid ngiography Lo position of anterior superior part of pericallosal rtery (⟷) which with ts branches extend abnormally far in the lateral direction within the lateral callosal sul rti t cistern (⟷) Drawing I ternal cerebral ein ( ) d placed laterally (→) as is the septal ein which del neates cavum septi

b

d



f

Fig 10 Complete callosal defect Carotid angiography lateral half axial supine and p ... encephalographic p view and composite drawing of lateral ... Anterior cerebral arteries unite in the midline to ... angle trunk closely following the anterior wall of the enlarged third ... entricle At the highest point th ... two main branches lie over the roof of the interhemispheric cyst and extend laterally into the cleftlike spaces between the cingulate gyri and the lateral callosal substitutes to their lateral termination where the ... essels turn upw ... rds The common trunk as well as the callosomarginal ... rteries are abnor mally wavy Middle cerebral artery group not changed Venous angles located higher and more posteriorly than normally (b) and the usual curv ... of the grea ... ein of Galen is distorted

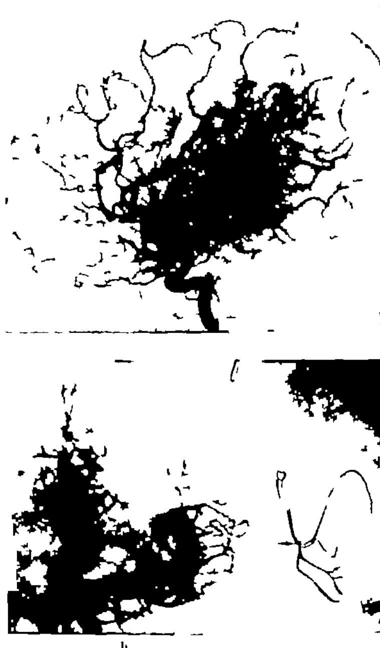


Fig 11 Partial callosal defect Carotid angiography Low position of anterior perior part of pericallosal rtery (⟷) which with its branches extend abnormally far in the lateral direction ... the lateral callosal sul ... tern (⟷) Drawing I ternal cerebral ... displaced laterally (⟶) as ... septal ... which delineates cavum septi



Fig 12 Schematic drawing showing the basic appearance of the pericallosal artery and its branches in cases with defects of the corpus callosum They deviate into the cleft between the marginal convolution and the lateral callosal substitute and turn round the marginal convolution ( )

The venous sinuses The confluens sinuum lay higher than normally in 2 cases (Fig 1 e) The transverse sinuses also occupied a similar high position from which they descended steeply towards the sigmoid sinuses The upward displacement of these venous sinuses and of the tentorium attachments was in both cases due to the presence of large cerebrospinal fluid cysts in the posterior fossa An uncommonly deep falx, which reached far into the interhemispheric fissure was present in 2 cases In one of these the anterior third of the superior sagittal sinus was absent while the inferior sagittal sinus was unusually wide

Discussion

This material has revealed that vascular anomalies of various types regularly occur in patients with defects of the corpus callosum, mainly in vessels closely related to the midline structures and the ventricular system Vessels as distantly situated as the middle cerebral artery and its branches did not deviate from the normal unless other abnormalities were also present (Fig 1)

The pericallosal artery had an abnormal course in all cases anomalies being demonstrated either in the inferior or superior part The former part of the artery usually ascended more abruptly than normally the anterior part was absent and replaced by a knee which was either rounded or more pointed In only one of the two cases with an anterior callosal rudiment the pericallosal artery followed and outlined it The superior part was in half the cases situated

The different angiographic abnormalities seem to vary in diagnostic significance As with the encephalographic changes, only a few of them possess conclusive evidence as an isolated phenomenon An integration of the vascular appearance of the arterial-capillary and venous phases into a complete picture is necessary for a conclusive understanding of the condition

SUMMARY

Carotid angiography was carried out in sixteen patients with encephalographically verified defects of the corpus callosum Vascular abnormalities in the arterial transitional and venous phases in varying combinations and of largely characteristic type were encountered in all cases They are discussed with regard to their value as evidence of callosal defects

ZUSAMMENFASSUNG

Die Karotis Angiographie wurde bei sechzehn Patienten mit encephalographisch nachgewiesenen Defekten des Corpus callosum ausgeführt Gefässveränderungen während der arteriellen, der Übergangs und der venösen Phase in verschiedenen Kombinationen und von sehr charakteristischem Bild wurden in allen Fällen angetroffen Diese werden hinsichtlich ihres Wertes als Beweis eines Callosum Defektes diskutiert

RÉSUMÉ

Une angiographie carotidienne a été faite chez seize malades atteints de malformations du corps calleux vérifiées par encephalographie Dans tous les cas on a constaté des anomalies vasculaires aux phases artérielle intermédiaire et veineuse en combinaisons variables et de type très caractéristique Les auteurs étudient leur valeur comme signes de malformations du corps calleux

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of the corpus callosum Such lateral curves would not be possible without corresponding clefts in the medial wall of the hemispheres—the cisterns of the lateral callosal substitutes This feature, as well as the course of the arteries curving around the marginal convolution, produces the pathognomonic appearance that may appropriately be called the callosal defect deformity of the pericallosal artery The laterally displaced branches in the pericallosal cistern and the negative image of the ventricular system are other characteristic signs

Abnormalities of the deep venous system were always present and of great diversity often characteristic A marked ipsilateral location of the internal cerebral vein occurred in just over half the cases, depending on the degree of dilatation of the third ventricle it can probably be taken as a useful indicator suggesting the presence of a corpus callosum defect if due consideration be paid to other relevant abnormalities Displacement due to pressure from the other side or traction due to an ipsilateral reduction of hemisphere volume need to be excluded An abnormally high position of the deep cerebral veins, and an abnormal relation of these vessels to the inferior sagittal sinus and the pericallosal artery may also be encountered (LARSEN)

Abnormal shortness of the internal cerebral veins, which appears to be a reflection of wide foramina of Monro and absence of the normal curve of the vena magna were often demonstrated

The subependymal tributaries of the internal cerebral vein indicate the boundaries of the lateral ventricles Each vein must be identified in both a p and lateral views The location in the half axial a p projection correlated with that in the lateral view gives the best assessment of the course and sites of origin of the afferent veins An ipsilateral displaced internal cerebral vein similar displacement of the thalamostriate vein with a narrow or at least not widened arch combined with long trigone veins widely distributed, may be regarded as the typical appearance in callosal defects These features in addition to the separation reflect discrepancy in the width between the anterior and posterior parts of the lateral ventricles (cf PROBST 1973)

The anomalies of the venous sinuses in the posterior fossa seem to have been the result of abnormal pressure conditions in that region which prevented the tentorial attachment from descending They were thus not related to the absence of the corpus callosum but constituted a developmental disturbance traceable to an associated malformation in the posterior fossa The occurrence of common pericallosal trunks (in 3 out of 16 cases) was probably not incidental it might be a vascular dysplasia with a direct relationship with the same defective developmental mechanism as that leading to the callosal defect However this anomaly not infrequently occurs also in normal brains (in about 4 per cent of cases LE MAY & GOODING 1966)

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THE COCHLEAR AQUEDUCT

ANDERS HEMMINGSSON and PER GUNNAR LINDGREN

Histologic examinations of the cochlear aqueduct were performed some decades ago by KARLEFORS (1924) MEURMAN (1930) and KARBOWSKI (1930) among others, and more recently by WALTNER (1947 1948) ANSON et coll (1964 1965) RITTER & LAWRENCE (1965) HENNEFORD & LINDSAY (1968) PALVA & DAMMERT (1969) and PALVA (1970) Opinions differ as to whether or not the aqueduct is open and allows free passage of cerebrospinal fluid from the subarachnoid space to the scala tympani PALVA & DAMMERT however concluded that fluid exchange through the cochlear aqueduct was fully feasible but stated that its course and structure are not sufficiently known, for instance in cases of Meniere s disease According to DORPH et coll (1973) an unusually wide aqueduct may be a possible cause of fistulas following stapedectomies

The present investigation was therefore undertaken to determine whether the cochlear aqueduct can be demonstrated at roentgen examinations of temporal bone specimens as well as of living subjects To our knowledge the roentgenologic appearance of the whole cochlear aqueduct has not been described previously

Anatomy The cochlear aqueduct contains the cochlear canaliculus which passes from the subarachnoid space in the posterior cranial fossa to the peri

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Table

Number of cases with the cochlear aqueduct visible in its entire length

Diagnosis	Age (in years)			Total
	< 10	10–20	> 20	
Normal	3/3	1/2	3/5	7/10
Menière disease			7/9	7/9
Fracture			0/2	0/2
Otitis chronica		1/2	4/16	5/18
Otosclerosis			1/1	1/1
Carcinoma			1/1	1/1
Total	3/3	2/4	16/34	21/41

examined histologically by PALVA & DAMMERT the smallest width was 80 to 150 that is about 0 1 to 0 15 mm and the width gradually increased in both directions, to about 0 2 to 0 5 mm at the internal orifice and about 0 5 to 2 4 mm at the external aperture At histology PALVA (1970) found that in six infant temporal bones the width of the cochlear aqueduct was somewhat greater than in adults The length of the aqueduct measured from the bottom of the external aperture to the internal orifice at the scala tympani averaged 6 mm in adults (PALVA & DAMMERT) and 3 5 mm in infants (PALVA)

Material and Method To determine the best projection for demonstrating the cochlear aqueduct at roentgen examination a titanium thread with a diameter of 0 1 mm was introduced into the aqueduct in eight adult temporal bones None of the subjects from whom these bones were taken had had any history of ear disease The specimens were examined in true a p projection, in a p projection with medial and lateral rotations in 5 steps and in axial projection with 5 steps of medial and lateral inclination

The aqueduct was uncovered by means of a dental drill (Fig 2) to confirm that the thread lay in the correct position

Eight specimens without a thread and 41 patients were also examined in the a p projection found optimal for demonstration of the aqueduct in the specimens with the titanium thread The ages and diagnoses of the patients are given in the Table

A Polytome was used with 0 5 mm cuts and hypocycloidal movement the focal spot was 0 3 mm The new Kodak X-omatic Fine film screen system was used for the specimens and the Kodak X-omatic Regular film screen system for

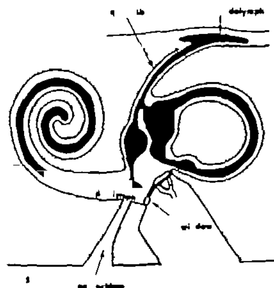


Fig. 1. Perilymphatic and endolymphatic spaces.

lymphatic space in the basal coil of the cochlea (Fig. 1). This space surrounds the membrane wall in the cochlear duct, the utricle, the saccule and the semicircular canals. The chemical compositions of perilymph and endolymph are different; immunologically the perilymph seems to be similar to CSF (PALVA & DAMMERT 1969).

The external aperture of the cochlear aqueduct is funnel-shaped; the aqueduct gradually narrows to the smallest width 0.5 to 1.5 mm from the internal orifice to the scala tympani, after which it again widens. In 20 adult bone specimens



Fig. Photograph of specimen with the titanium thread in the exposed aqueduct.



Fig 5 Tomogram in the 5 p projection of an dult patient with Meniere disease The entire length of the cochlear aqued ct (→) is ible





b

Fig 6 Tomograms f the same specimen as in Fig 4) F lm screen combination Kodak RPL f lm—Siemens Universal screens b) Kodak G f lm—Kodak X omatic Regular screens The noise is most evident ( )

Results

The whole thread length in the aqueduct from the external aperture to the internal orifice was demonstrated in a p projection with the temporal bone rotated 5 laterally (Fig 3 a) i e the head should be turned 5 from the straight a p position towards the transorbital Guillen projection The axial projection with 20 medial inclination (Fig 3 b) al o demonstrated the whole thread

The aqueduct of the specimens without the thread (Fig 4) could be observed in its entire length in 6 of the 8 bones in the a p view with 5 lateral rotation and in the axial view with 20 medial inclination The short aqueducts were nearly straight in their downward course (Fig 4 a) while the longer ones were slightly curved (Fig 4 b)



Fig 3 Tomogram of specimen in) 5 a p and b) 20 axial projections A titanium thread (→) has been placed in the cochlear aqueduct 1 = superior semicircular canal 2 = internal acoustic meatus 3 = horizontal semicircular canal 4 = cochlea 5 = middle ear

the patient. The exposure data were 55 kV 6 4 s 10 mA for the former and 65 kV 12 8 s 32 mA for the latter General (G) Kodak film was used in both systems

The resolution capacity and the noise level of the Kodak X omatic Regular system was compared with those of Siemens Universal screens combined with Kodak RPL film by means of tomograms of the same specimen exposed with the same data



Fig 4 Tomogram of specimens in) b) the 5 p and) 20 axial projection The longer cochlear aqueduct in (b) is more curved in its downward course tha the shorter or ( ) Arrows indicat the aqueduct



Fig 5 Tomogram in the 5 p projec tion of n adult patient with Meniere disease The entir length of the coch lear queduct (→) is isible





b

F g 6 Tomograms of the same specimen as in Fig 4) Film screen combination Kodak RPL f lm—Siemens Universal screens b) Kodak G film—Kodak X omatic Regular screens Th bone is most ident in (a)

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The bony structure was more clearly visible and the noise level lower in tomograms with the Kodak X-omatic than with the conventional film screen system (Fig 6)

Discussion

This investigation has revealed that for examination of the cochlear aqueduct a p projection with 5 rotation of the head towards the tran orbital (Guillen) projection or axial projection with 20 medial inclination should be used These projections seem to be more appropriate than the 37 a p projection described by DORPH et coll (1973) The aqueduct was demonstrated in most specimens which supports the view of PALVA & DAMMERT that at least its bony part is open

The aqueduct could be demonstrated in about half of the patients (Table) It was most difficult to outline in patients with chronic otitis probably because of the sclerotic bone in these cases It could be observed in most of the adult normal subjects as well as in all children In this small material there was no difference between normal subjects and patients with Meniere s disease

The small diameter of the cochlear aqueduct places high demands upon the tomographic equipment and the film screen system The new Kodak X-omatic system has lower unsharpness and a lower noise level (REICHMANN & HELANDER 1974) than the conventional systems (Fig 6) which is of importance for the demonstration of small structures with low contrast

Conclusion

The entire length of the cochlear aqueduct may be outlined in tomograms with an inclination of the head 5 laterally and 20 medially in a p and axial projections respectively The shape and course of the aqueduct varied In the present clinical material it could be observed in about half of the 41 cases

The new Kodak X omatic film screen system with its low noise level and low geometric unsharpness seems to be an improvement in the rendering of details in ear tomograms

SUMMARY

The cochlear aqueduct could be demonstrated t tomography of temporal bon speci mens and in about half f the cases in clinical material in p projection with 5 lateral rotation and in axial projection with 20 medial inclination N difference betw een normal subjects and patients with Meniere di ease was encountered

troduced by CAMPBELL et coll (1964) for lumbar myelography it rapidly gained popularity owing to its excellent contrast producing properties, rapid resorption from the subarachnoid space and low toxicity making spinal anaesthesia unnecessary Notwithstanding, the present authors (AUTIO et coll 1972) reported a high incidence of adhesive arachnoiditis after lumbar myelography with 7 ml meglumine iothalamate in patients subjected to repeat myelography without intervening operative procedures The main radiographic features of adhesive arachnoiditis were obliterated root sleeves disappearance of the striated appearances of the intrathecal nerve roots and constriction of the dural sac the adhesions were most marked in the lowermost sacral root sleeves The observations were soon confirmed by RADBERG & WENNBERG (1973) and HALABURT & LESTER (1973)

The question then arose as to whether the intrathecal reactions observed could be attributed partly to the physico chemical properties of the agents Preliminary experiments revealed that the pH changes in the cerebrospinal fluid (CSF) after instillation of contrast media were small whereas the concentrated contrast solutions hyperosmolal in comparison with the CSF induced a dose dependent increase of osmolality in samples taken after their addition in vitro The high osmotic gradient between the CSF and the neural elements, regarded as a factor potentially contributing to the adhesive arachnoiditis after lumbar myelography called for further clinical analysis

Alterations in the osmolality of the CSF in this clinical series during and after routine lumbar myelography with different contrast media, were compared with the data on the incidence and site of lesions radiographically observable The results indicated a close relationship between osmolal disturbances in the CSF and the occurrence of adhesive arachnoiditis

Material and methods The series comprised 41 patients subjected to lumbar myelography on account of sciatic pain In 10 patients, the osmolality of the CSF was measured in connection with the first myelography according to the schedule described in another 31 patients the position and severity of adhesive arachnoiditis demonstrable were determined from films obtained from the first and a repeat myelography without intervening operative procedures

The first myelography had been made with 10 ml Kontrast U (sodium methiodal) in 14 patients, with 7 ml Conray Meglumin 282 (meglumine iothalamate) in 13 patients and with 5 ml Dimer X (meglumine iocarmate) in 4 patients

Lumbar myelography was carried out with the patient lying on the left side on a roentgen couch tilted head up from about 10 to 40 degrees Spinal anaesthesia with 1 5 ml Xylocain tung preceded injection of the Kontrast U

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HYPEROSMOLALITY OF THE CEREBROSPINAL FLUID AS A CAUSE OF ADHESIVE ARACHNOIDITIS IN LUMBAR MYELOGRAPHY

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Contrast media injected into the lumbar subarachnoid space affect the leptomeninges and cause either histologically visible reactions or clinically demonstrable irritation of the nerve roots HARVEY & FREIBERGER (1965) reviewed the adverse local effects of water soluble sodium methiodal (Abrodil Conturex Kontrast U) and demonstrated dose dependent toxic effects on leptomeningeal structures and nerves in dogs PRAESTHOLM & OLGAARD (1972) presented similar evidence of leptomeningeal reactions after meglumine iothalamate (Conray) reporting cell infiltration into the meninges after subarachnoid instillation of the medium in rabbits

Clinically the water soluble contrast media hitherto used for lumbar myelography have caused notable irritation of the neural elements and spinal anaesthesia before their use has become mandatory Reports of severe neurologic complications have appeared (LINDBLOM 1947 PANTER 1953 MUNRO 1956 SODERBERG et coll 1958 BIDSTRUP 1972 Hence when meglumine iothalamate was in

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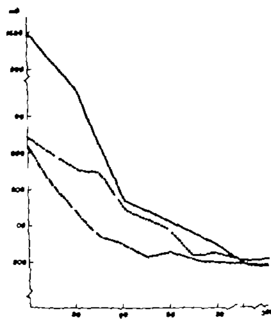


Fig 1 Osmolality [illegible] lues of the [illegible] cerebrospinal fluid after injection of [illegible] arious contrast media —— Kontrast U (10 ml) [illegible] Conray Meglumin ([illegible] ml) — — Dimer X (7 ml)

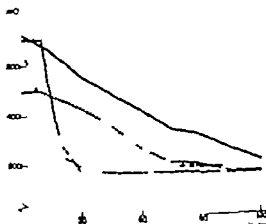


Fig 2 Osmolality [illegible] alues [illegible] f the cerebrospinal fluid [illegible] different levels after injection of Dimer X —— L5/S1 (4 5 ml) [illegible] L5/S1 (4 0 ml) — — — L4/L5 (7 0 ml) — — L5/L4 (5 0 ml)

Osmolality of the CSF at different levels after injection of varius contrast media Three lumbar needles were introduced through the three lowermost lumbar interarcuate ligaments into the subarachnoid space Samples were taken from the L3/L4 the L4/L5 and the L5/S1 segments after injection of contrast media

Table 1 indicates that the highest values for osmolality were recorded in the lowermost segment L5/S1 regardless of the contrast medium Hyperosmolality was most notable after the injection of Kontrast U and least after the adminis

Table 1

Osmolality (mOsm/kg H O) of the cerebrospinal fluid taken from the three lowermost lumbar segments 1 to 2 min after subarachnoid injection of various contrast media

Contrast medium and amount injected		Osmolality of the CSF af er injection of the medium measured at the lev 1 of		
		L3/L4	L4/L5	L5/S1
Kontrast U	(10 ml)	1 190	1 400	1 500
Conray	(ml)	520	550	550
Conray	(7 ml)	620	620	640
Dimer X	(5 ml)	450	480	540
Dimer X	(5 ml)	450	460	4[illegible]0
Dimer X	(7 ml)	520	590	6[illegible]

it was not performed in patients subjected to lumbar myelography with Conray Meglumin 282 or Dimer X. Initially 7 ml Conray was thoroughly mixed with 3 ml of CSF. Appropriate films were obtained in lateral, prone and both oblique projections with a vertical beam in the TV image intensifier. The contrast medium was not aspirated. The patient was instructed to remain in a semirecumbent position for 6 hours after completion of the examination.

Osmolality was obtained with a Fiske osmometer by measuring the freezing point depression in samples of CSF. The normal osmolality of the CSF, as of the intra- and extracellular fluids, is 290 ± 10 mOsm/kg H O.

Samples of CSF were obtained during and after myelography either through single lumbar needles or three simultaneously inserted lumbar needles. Care was taken to achieve their proper positioning. After injection of the contrast medium 1 to 2 minutes was allowed for equilibration before the first ample was taken; further samples were obtained, if necessary, at 15 minute intervals. Analysis of the films from the primary and the repeat myelography revealed signs of adhesive arachnoiditis at the second examination. The changes were classified according to the position and severity into four stages, stage 0 indicating a normal myelography and stage III gross adhesions and constriction of the leptomeningeal spaces.

Results

The osmolality of the CSF rose instantly to high values after injection of the contrast media. The changes seemed to be dose dependent and related to the medium.



F 3) First myelographs with 10 ml Kontrast U Good filling of the lumbar and sacral root sleeves b At repeat examination with Conray disappearance of the striated structure in the lower part of the dural sac which is moderately constricted The left sacral root pouches remain unfilled and the left L5 root sleeve is blunted Stage II alterations

Fig 4 a) First myelography with 7 ml Conray oblique Good filling of the root sleeves with small cystic dilatation of one sacral root pouch b) At repeat examination the sacral and L5 root sleeves remain unfilled The dural sac is moderately constricted Stage II alterations

Fig 5 Myelographies with ml Dimer X a) First myelography Protrusion of the vertebral disc L5/S1 on the right side b) Second myelography without intervening operation. Good filling of all unaffected root sleeves The striated structure of the dural sac is retained No adhesions stage 0

Conray in a moderate dose (4 ml) raised the osmolality of the CSF to 730 mOsm/kg H_2O In another patient injection of 5 ml Conray increased the osmolality to 550 mOsm/kg H_2O and a further addition of 2 ml Conray raised this to 610 mOsm/kg H_2O

Dimer X (4 ml) induced an osmolality of 450 mOsm/kg H_2O in another patient 4 5 ml caused a corresponding increase to 560 mOsm/kg H_2O In 3 patients injection of 5 ml Dimer X raised the osmolality values of the CSF to 475 540 and 560 mOsm/kg H_2O respectively In another patient 5 ml Dimer X increased the osmolality to 470 mOsm/kg H_2O and the addition of 2 ml medium raised the osmolality to 625 mOsm/kg H_2O

These results suggested that the addition of 2 ml of contrast medium to raise it from 5 to 7 ml increased the osmolality of the CSF by 90 to 155 mOsm/kg H_2O

tration of 5 ml Dimer X. No value obtained was within the normal range thus the area defined in the films by the medium contained a cerebrospinal fluid with hyperosmolal properties the values being most aberrant in the lowermost segments

Spinal anaesthesia with 1.5 ml lidocain induced displacement in CSF osmolality from the normal value of 290 mOsm/kg H_2O to 530 mOsm/kg H_2O at the level of L5/S1. The extremely high value after the subsequent injection of Kontrast U (1 500 mOsm/kg H_2O) obviously reflected an additive effect of the two media instilled into the subarachnoid space

Osmolality of the CSF 6 hours after injection of various contrast media The duration of the hyperosmolal state in the lumbar area after myelography was determined as follows the lumbar needle was introduced through the L5/S1 interarcuate ligament into the subarachnoid space and after completion of the examination samples were taken at 15 minute intervals for two hours and subsequently by repeated spinal punctures at two-hour intervals until six hours after the examination. The osmolality curves have been compiled in Fig 1. After injection of Kontrast U the initial value of 1 500 mOsm/kg H_2O fell rapidly to 480 mOsm/kg H_2O within one hour but the osmolality values were not normal until four hours after injection of the contrast medium this may be attributed partly to the slow resorption of lidocain. Conray (7 ml) induced a CSF osmolality of 640 mOsm/kg H_2O and the values for the successive samples reached almost normal levels within two hours. Dimer X (7 ml) induced slightly lower initial osmolality values, and the decline of the curve was even more rapid (Fig 1). Six hours after injection of the media all values obtained were within the normal range

Osmolality of the CSF at different levels after injection of Dimer X Lumbar needles were introduced through the three lowermost interarcuate ligaments into the subarachnoid space and serial samples taken during two hours (Fig 2). The declining curves of the osmolal values had different inclinations at the three lumbar levels. Osmolality remained high at the L5/S1 level but rapidly returned to values within the normal range in the higher segments

Osmolality after injection of various amounts of Conray and Dimer X The influence of increasing amounts of contrast medium on the osmolality value was determined. The lumbar needle was introduced through the L5/S1 interarcuate ligament into the subarachnoid space and CSF samples taken after instillation of different amounts of contrast media

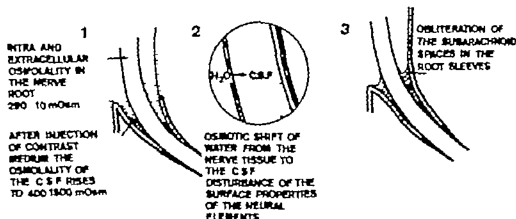


Fig 6 Changes in the osmolal equilibrium of the cerebrospinal fluid after injection of contrast media and assumed sequence of events resulting in adhesive arachnoiditis

brospinal fluid Of the different media tested sodium methiodal caused an increase of the CSF osmolality from the normal 290 mOsm/kg H_2O to 1 500 mOsm/kg H_2O far surpassing the values obtained with other media It should be noted that this is the only contrast medium of the present series which requires spinal anaesthesia before its injection The other media (Conray and Dimer X have a less profound influence on the osmolal equilibrium of the CSF and may be used without anaesthesia, but signs of irritation of the nerve roots such as tic movements and muscle spasm have been reported (AHLGREN 1969 EDGREN & TALLROTH 1970 IRSTAM et coll 1970 PRAESTHOLM & LESTER 1970 GONSETTE 1971 AUTIO et coll 1972, HAMMER & SCHERRER 1972 LEHTINEN & SEPPANEN 1972)

The osmolal values measured at different levels revealed the highest values in the lowermost part of the cul de sac they remained high long after they had reached normal levels in the upper segments High osmolality values were still recorded one hour after injection of the contrast medium this corresponds to the period when media may still be observed in the films

The hyperosmolal state occurring in the lumbar subarachnoid space after instillation of media is dependent both on the medium and on the amount injected The osmotic pressure induced by any given substance dissolved in water is based upon the number of particles of solute in solution and not on characteristics of weight electrical charge, or shape of the dissolved particle (BOYD & BAKER 1971) Much can be done to reduce the osmolal properties of contrast media available by reducing the number of particles producing a given amount of contrast the physicochemical properties of Dimer X are more favourable in this respect than the other media used in this series

Table 2

Frequency and severity of adhesive arachnoiditis after various water soluble contrast media

Contrast medium		No. of patients	Severity of adhesive arachnoiditis			
			0	I	II	III
Kontrast U	(10 ml)	14	5	4	4	1
Conray Meglumin 282	(7 ml)	13	2	7		
Dimer X	(5 ml)	4	4			

Comparison of the films from the two successive myelographies revealed characteristic alterations: the first and constant sign of adhesive arachnoiditis was obliteration of the sacral root sleeves and disappearance of the normal striated structure of the lowermost dural sac. If the reaction was more profound, similar changes could be observed in the lumbar root sleeves advancing cephalad from L5. The dural sac in severe cases appeared constricted. The following radiologic classification was made on this basis (Figs. 3, 4, 5).

Stage 0 No signs of adhesive arachnoiditis in the root sleeves or dural sac.

Stage I Obliteration of the sacral root pouches and disappearance of the striated structure normally visible in the dural sac.

Stage II The sacral root sleeves remain unfilled; the fifth lumbar root sleeves are blunted. The dural sac is moderately constricted at the level of the fifth lumbar vertebra.

Stage III All sacral root pouches and the fifth lumbar root sleeve remain unfilled; the fourth lumbar sleeve is blunted. The dural sac is severely constricted at the level of the fifth lumbar vertebra.

The series was subdivided according to this classification and the contrast medium (Table 2). It emerged that 10 ml Kontrast U and 7 ml Conray Meglumin induced adhesive arachnoiditis of approximately equal severity. It should be noted that of the patients examined with Kontrast U and Conray Meglumin 5/14 and 2/13 respectively had no untoward reactions at repeat myelography. In the small group examined with Dimer X no adhesion could be demonstrated at repeat myelography and this medium thus appeared to cause only a low incidence of arachnoiditis.

Discussion

This investigation indicates that the commonly used contrast media, when injected into the subarachnoid space, induce hyperosmolal changes in the cere-

been erroneously assumed to be postoperative adhesions in retrospect it is evident that most of these patients had adhesive arachnoiditis This has also been pointed out by HALABURT & LESTER (1973) Myelography may still be used in clinical practice the indications should be strictly delineated a small amount of contrast medium should be used, and the manufacturers should pay due attention to the osmolal properties of their products

SUMMARY

Adhesive arachnoiditis was frequently observed after lumbar myelography with 10 ml Kontrast U and 7 ml Conray Meglumin 282 but not with 5 ml Dimer X These water soluble contrast media induced hyperosmolality of the cerebrospinal fluid related both to their type and the amount injected the degree of hyperosmolality was correlated to the severity of the subsequent adhesive arachnoiditis Dimer X produced the lowest changes

ZUSAMMENFASSUNG

Eine adhäsive Arachnoiditis wurde häufig nach lumbaler Myelographie mit 10 ml Kontrast U und 7 ml Conray Meglumin 282 jedoch nicht mit 5 ml Dimer X beobachtet Diese wasserlöslichen Kontrastmittel verursachen eine Hyperosmolalität der Cerebrospinal flüssigkeit die sowohl zu deren Typ als auch zur injizierten Menge relatiert war der Grad der Hyperosmolalität war zum Ausmass der nachfolgenden adhäsiven Arachnoiditis korreliert Dimer X hatte die geringsten Veränderungen zur Folge

RÉSUMÉ

Les auteurs ont observé fréquemment une arachnoïdite adhésive après radiculographie lombo sacrée faite avec 10 ml de Kontrast U et 7 ml de Conray Meglumin 282 mais pas avec 5 ml de Dimer X Ces moyens de contraste hydrosolubles provoquent une hyperosmolalité du liquide céphalo-rachidien en rapport à la fois avec leur type et avec la quantité injectée le degré d'hyperosmolalité est en rapport avec la gravité de l'arachnoïdite adhésive ultérieure C'est le Dimer X qui donne les modifications les plus faibles

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Dilution experiments in our laboratories have revealed that dilution of Dimer X with distilled water in a ratio of 1 1 gives a solution with an osmolality of 480 mOsm/kg H O whereas mixing the contrast medium with CSF increases the osmolality of the solution to 620 mOsm/kg H_2O This indicates that in clinical work the medium should be diluted with distilled water not with CSF before it is injected into the subarachnoid space

It was also demonstrated that the amount of medium should be kept at a minimum at low doses of Conray and Dimer X, the osmolality of the CSF remains reasonably low (Fig 2) and thus is correlated with a lower frequency of adhesive arachnoiditis (Table ?) If the osmolality of the CSF can be kept below 500 mOsm/kg H O during lumbar myelography the occurrence of adhesive reactions is in the light of the present series unlikely The importance of low doses of contrast media was recently stressed by HALABURT & LESTER (1973) who noted a decrease in the incidence of adhesive arachnoiditis from 80 to 10 per cent when the dose of Conray was lowered from 7 5 to 5 ml

A possible explanation of the chain of events that follow instillation of media and ultimately result in adhesive arachnoiditis is given in Fig 6 Injection of a hyperosmolal contrast solution into the subarachnoid space suddenly increases the osmolality of the cerebrospinal fluid The osmotic gradient between the fluid on the one hand and the cells of the surrounding tissue on the other increases the displacement of water through the cell membrane to the subarachnoid space This gradient is highest in the lowermost part of the dural sac and primarily affects the sacral roots where surface injury to the neural elements is most probable The injury to the delicate surface structures of the neural roots and root pouches may be accomplished either by mechanical disintegration of the surface cells or by cell death due to extensive dehydration or both The subarachnoid tissue then adheres to the pia around the root sleeves and obliterates these The tissue lesion is partly covered with fibrous tissue which causes gradual constriction of the dural sac Such leptomeningeal fibrosis has been described in dogs by HARVEY & FREIBERGER (1965) and in rabbits by ZETTLER (1969) and PRAESTHOLM & OLGAARD (1972)

Control examinations of the present material have been made since these radiologic features became evident So far however few if any signs or symptoms of arachnoiditis have been detected clinically The difficulties in this respect should be emphasized since many of the patients have low back pain of long standing with or without previous neurologic signs and an accurate differential diagnosis is often impossibl The main drawback of the radiologic signs of adhesive arachnoiditis is the blurring eff t of successive myelographies which renders their interpretation difficult M any of the myelographic changes observed during previous y ars in patients ubjected to operation have obviously

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DIFFERENTIAL DIAGNOSIS OF SPACE OCCUPYING LESIONS IN THE KIDNEYS WITH THE SCINTILLATION CAMERA

S. NORDLANDER and P. J. ÅSARD

Radiology of patients with possible renal tumours is often trying for the patients. This holds especially true for the old patient with a renal mass lesion accidentally detected, for instance at urography for a prostatic lesion. A method less trying for the patient than angiography but allowing differentiation of malignant tumours from benign cysts with the same degree of accuracy has been desired since a long time. The results with scintigraphy of the kidneys using the scintillation camera is now reported. Similar methods have been described previously (BLACK et coll. 1966, ROSENTHALL 1967).

Material

Renal mass lesions detected at urography were examined by the scintillation camera, nephroangiography and percutaneous renal puncture; the results were compared and correlated to microscopy of the operation specimen. The material consisted of 38 patients, of these only 3 were women. The mean age was 64

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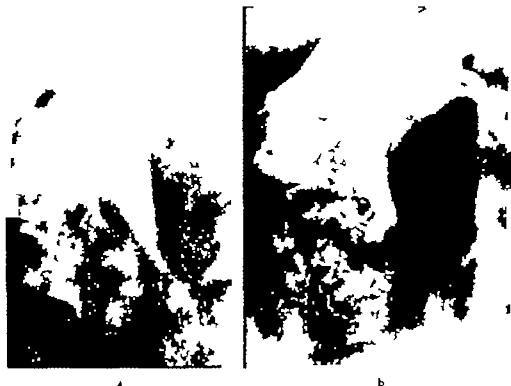


Fig 1 R ht renal rc ioma U ography b) Angiography

Results

Of the 38 patients 9 were considered to have renal carcinoma 2? cysts while the remaining patients had other renal lesions The diagnosis of carcinoma was verified in 8 cases by microscopy usually both by fine needle biopsy and later by examination of the specimen after nephrectomy In one patient microscopic verification was not obtained as this patient had rapidly increasing pulmonary metastases and operation was considered meaningless

The benign renal cysts were usually single but in some cases multiple often located in both kidneys The smallest cyst, verified by puncture had a diameter of about 4 cm but defects with a diameter of about 2 cm were observed on some scintigrams In 14 patients the diagnosis of cyst was verified either by angiography with demonstration of round well circumscribed avascular areas (5 patients) or by percutaneous puncture with injection of contrast medium (9 patients)

years The predominance of old males depended on the fact that most patients were admitted from the urologic clinic, where the frequency of patients with prostatic disturbances was high

Method

All patients were examined with a Nuclear Chicago Pho Gamma III HP equipped with a tape recorder (direct store system) and a persistence oscilloscope The examination was performed in two stages First the circulation in the kidney with the possible lesion was recorded and then scintigrams of both kidneys were obtained in different projections

As a rule a cannula was inserted into a brachial vein before the examination The patient was placed prone with the collimator of the scintillation camera centred on the aorta and the possibly diseased kidney its position had previously been determined on a roentgen film Ten mCi $^{99}Tc^{m}$ DTPA (Renotec) or $^{99}Tc^{m}$ iron ascorbic acid complex were rapidly injected and the cannula flushed with physiologic saline The examination was performed while the patient held his breath in deep inspiration in order to avoid blurring By this means the background activity from liver and spleen could also be diminished during the recording of the circulation This was obtained on the video-tape during 60 s with a high sensitivity collimator

The video tape was then replayed and the circulation documented by sequential views, usually with an interval of 5 s Immediately afterwards a static scintigram was taken (300 000 counts) the patient lying exactly in the same position Scintigrams of the two kidneys were then taken 1 to 3 hours after the injection, depending on the renal function During the recording the patient was instructed to breath with a shallow respiration in order to diminish th respiratory movements of the kidney

Different types of collimators were used high resolution high sensitivity and pinhole collimators In some ca es the collimator was tilted about 15 medially toward the kidney for better demonstration of defects in the renal parenchyma

The perfusion of the kidney was evaluated from the sequential views the function of the renal parenchyma was assessed by the accumulation of the isotope on the scintigrams

A renal cyst was considered to be present in those cases where a defect in the renal perfusion corresponded with a defect of the same size and shape on the static scintigram i e a non vascular region of the kidney without functioning parenchyma a malignant tumour was diagnosed when the recording of the circulation demonstrated a reg on with increased activity compared to the surrounding tissue and decreased accumulation on the static scintigram i e increased vascularity without functioning parenchyma



Fig 3 Renal cyst Urography with tomography

The scintigraphically diagnosed renal lesions considered as cysts were not further examined in 6 patients. These were mainly old patients with prostatic disease considered non operable.

The scintigraphic diagnosis was erroneous in two patients. They had renal mass lesions which scintigraphically were considered to be well circumscribed areas with poor vascularization, similar to cysts. At percutaneous puncture, however, it was not possible to obtain any fluid. On the contrary, malignant cells were aspirated from the mass at fine needle biopsy. Nephrectomy was performed and the malignant tumours were in both cases necrotic in the center, which explained the similarity to cyst on the scintigram.

Seven patients had other renal abnormalities than carcinoma or cyst. One of these patients had in the lower pole of one kidney a bulge similar to a tumour. At scintigraphy no abnormality could be detected. Previously a nephrolithotomy had been performed and the bulge was probably a postoperative deformity.

At urography of another patient with prostatic lesion a kidney without function was found. No circulation through the kidney could be detected at

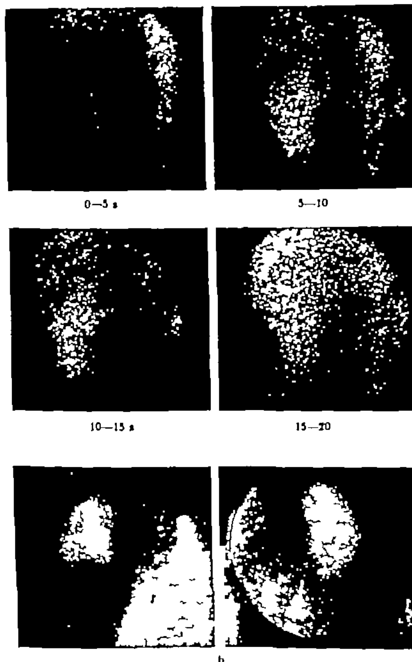


Fig Same case as in Fig 1) Circulation in right kidney recorded with 10 mCi ^{99m}Tc DTPA Interval of five seconds bet each sequential image b) Scintigraphy of both kidneys one hour after injection 300 000 unt high resolution collimator

scintigraphy and an obliteration of the renal artery was considered probable. At nephroangiography, however, a very small artery could be demonstrated and at renal phlebography veins in a capsule of a hydronephrotic kidney could be demonstrated. An enlarged prostatic gland had caused an obstruction to the urinary outflow from the kidney, thus producing the hydronephrosis. Following the atrophy of the renal parenchyma the renal artery had diminished in width which explained that a clear understanding of the pathology could not be obtained at nephroangiography or scintigraphy.

If expansive lesions existed or not was difficult to decide at scintigraphy of another case because of impaired perfusion. Urography with tomography demonstrated an abnormality of uncertain nature in the medial part of one kidney. At percutaneous puncture a benign cyst was found. The clinical diagnosis was chronic glomerulonephritis, which possibly could explain the impaired circulation.

In 4 patients with a similar urographic finding of small mass lesions at the renal hilum no abnormality could be detected at scintigraphy. Angiography was performed in two of these patients and by puncture in one. In all three cases nothing abnormal was found. Probably the urographic abnormality was caused by renal lipomatosis with small lipomatous masses in or around the renal hilum.

Discussion

The scintigrams are not comparable with ordinary angiographic films in resolution. The scintigraphy has, however, many advantages over angiography and is in some cases superior. Renal scintigraphy is not trying for old or deteriorated patients and is easily performed on out-patients. Preparations as for radiography (laxatives or enemas) can be omitted as intestinal content does not interfere with the result of the examination.

Another advantage over angiography is that an arterial puncture and insertion of a catheter with the accompanying risk of injury to the arterial wall is avoided. The injection of the isotope should be done through an intravenous cannula, the risk of a perivenous injection is diminished and it allows a rapid injection of the isotope as a bolus. The prerequisite for a good demonstration of the arterial phase of the renal circulation is thus fulfilled. The amount of the injected, non-specific material is much less than at conventional angiography. Contrast media for radiography may cause serious allergic reactions but such complications are not known following isotope injections.

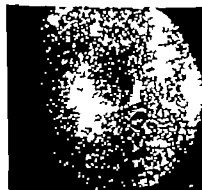
The radiation dose to the kidneys at scintigraphy with 10 mCi $^{99}Tc^{m}$ iron ascorbic acid complex or $^{99}Tc^{m}$ DTPA is about 1.2 and 0.4 rad respectively and the dose to the gonads 0.1 to 0.2 rad (GIMLETTE et coll. 1972, HAUSER et coll. 1970). This should be compared to the doses at nephroangiography, where the



0—5



5—10



10—15



15—20



b

Fig 4 Same case as in Fig 3 Circulation ... right kidney recorded with 10 mCi ^{99}Tc DTPA lateral ... of five seconds between each sequential image b) Scintigraphy of both kidneys one hour after injection 300 000 counts high resolution collimator

SUMMARY

The renal circulation and the function of the renal parenchyma have been analysed with $^{99}Tc^{m}$ DTPA or $^{99}Tc^{m}$ iron ascorbic acid complex in 38 patients with renal masses. The results have been correlated with angiography, percutaneous puncture and microscopy. The isotope method has allowed a differentiation between renal carcinomas and cysts. The method is to be regarded as a complement to urography and may replace nephroangiography in selected cases.

ZUSAMMENFASSUNG

Die Nierenzirkulation und die Funktion des Nierenparenchyms wurden bei 38 Patienten mit Nierenvergrösserung mittels $^{99}Tc^{m}$ DTPA oder $^{99}Tc^{m}$ Eisen-Askorbinsäure-Komplex untersucht. Die Ergebnisse wurden mit Angiographie, mit perkutanen Punktion und mit Mikroskopie korreliert. Die Isotopenmethode erlaubt es, zwischen einem renalen Karzinom und einer Zyste zu unterscheiden. Die Methode ist als ein Komplement zur Urographie anzusehen und kann in gewissen Fällen die Nierenangiographie ersetzen.

RÉSUMÉ

La circulation rénale et la fonction du parenchyme rénal ont été étudiées par $^{99}Tc^{m}$ DTPA ou par le complexe acide ascorbique fer $^{99}Tc^{m}$ chez 38 malades présentant des masses rénales. Les résultats ont été confrontés à ceux de l'angiographie, la ponction percutanée et la microscopie. Cette méthode isotopique a permis le diagnostic différentiel entre cancer du rein et kyste. Cette méthode doit être considérée comme un complément de l'urographie et peut remplacer la néphro-angiographie dans des cas sélectionnés.

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doses are equal or often higher Considering the radiation doses being rather equal at these types of examination the risk is about the same for the two methods

Renal scintigraphy is not meant to replace urography but is to be regarded as a complement By urography congenital or acquired renal abnormalities such as dysplasia pyelonephritis, tuberculosis can be detected the size of concretions determined and the wall of the urinary bladder demonstrated This is not possible with renal scintigraphy which should be used only on specific indications for instance for differentiating between a carcinoma and a cyst Renal scintigraphy can replace nephroangiography in such a case which is of particular value in old and deteriorated patients, in patients with disposition for pathologic bleeding (treatment with dicumarol or heparin) or in patients where difficulties at catheterization may be expected owing to vascular abnormalities The scintigraphic results seem to be almost as reliable as the angiographic ones A renal mass lesion with increased activity (vascularity) compared to the surrounding renal parenchyma is a malignant tumour with a high degree of accuracy with reservation for some rare conditions as vascular malformations and abscesses (carbuncle) In the latter case the clinical course usually indicates an inflammatory process Poorly vascularized masses on the other hand may sometimes offer diagnostic difficulties Necrotizing tumours are avascular centrally and often poorly vascularized in the periphery This results in less activity in the lesion than in the surrounding tissue and the appearance is similar to a cyst Two such cases exist in the material of 38 patients At nephroangiography similar diagnostic difficulties may be encountered but the small vessels in the periphery of a tumour may be demonstrated with the aid of specific drugs Cortical adenomas are poorly vascularized and may involve similar difficulties but no such tumours occurred in the material The sensitivity of the method does not allow demonstration of filling defects with a diameter of less than 2 to 3 cm The optimal resolution and the best possibilities to demonstrate small masses were found to be obtained by the pin hole collimator

Tumour thrombi in the renal veins may be demonstrated by selective nephroangiography using large amounts of contrast medium This is not possible at renal scintigraphy The isotope may however be injected in the femoral vein and a tumour thrombus floating from the renal vein into the vena cava may thus be demonstrated By combining isotope cavography and renal scintigraphy further diagnostic information may thus be obtained

By the present method morphologic information on renal abnormalities was obtained If a suitable radiopharmaceutical will be produced it is to be hoped that with the present method also the function of each kidney may be determined

Table 1

Data on 9 patients in group I

Age yrs	Site of tumor	Size of tumor (cm)	Histology of tumor	Axill met
60	diffuse (right)	diffuse	poorly diff. ca	yes
81	lat. (left)	1.5 × 1.5 × 1	lobular ca	no
56	centr. (left)	1 × 1 × 1	scirrhous ca	no
46	lat. (left)	2 × × 2	scirrhous ca	yes
74	lat. (left)	1 × 1 × 1	cribriformous adenocarcinoma	no
76	lat. (left)	diffuse	fibroadenoma	no
80	centr. (left)	2.5 × 1 × 2	scirrhous ca	no
76	lat. (right)	1 × 1 × 1	poorly diff. adenoca	no
71	lat. (right)	4 × 3 × 1.5	scirrhous and medullary adenoca	yes

Knowledge of the spread of a neoplasm is essential if the operation or the postoperative irradiation techniques are to be modified. The main means of diagnosis for the parasternal lymph is scintigraphy. Most reports on parasternal scintigraphy have dealt with ^{198}Au colloid (ROSSI & FERRI 1966, SCHENK 1966, DIETHELM et coll. 1967, SCHENK et coll. 1966, MICHAILOV et coll. 1968, KAZEM et coll. 1968, 1969, ROSSI et coll. 1968, SEIFERT & BETZNER 1970, MEYER-BURG & WILHELMI 1971, GROS et coll. 1969, 1972).

The use of ^{99m}Tc^{m}S colloid has been suggested by GORANSON et coll. (1973) and GORANSON & JONSSON (1974). Two different techniques for parasternal scintigraphy have been used in experimental animals: a transabdominal technique with injection of the colloid into the peritoneal cavity (GORANSON et coll. 1973), the other with injection of the colloid, mixed with hyaluronidase, into the soft tissue on both sides of the xiphoid process (GORANSON & JONSSON 1974 a). The purpose of the present investigation was to determine whether these two techniques could be used in human subjects. As no surgical information regarding the parasternal lymph nodes was obtained, comparison between the findings at scintigraphy and the histology of the lymph nodes was not possible.

Material and Methods. All the patients had a palpable tumour of the breast and fine needle aspiration biopsy had verified carcinoma. Biopsy was performed before the scintigraphy in one patient. The ^{99m}Tc^{m}S-colloid was prepared ac-

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PARASTERNAL SCINTIGRAPHY WITH TECHNETIUM 99m SULFIDE COLLOID IN HUMAN SUBJECTS

A comparison between two techniques

L R GÖRANSON and K JONSSON

Lymph from the breast drains in two main directions to the axillary and parasternal lymph nodes HULTBORN et coll (1955) demonstrated by the radio active tracer technique that the lymphatic drainage from all parts of the breast is to both these primary groups of lymph nodes The clinical implication of this is well documented in reports on the spread of carcinoma of the breast ANDREASSEN et coll (1954) reported metastases in parasternal lymph nodes in a third of medially located carcinomas of the breast and in a tenth of lateral carcinomas of the breast URBAN & MARJANI (1971) observed axillary metastases in 47 and parasternal metastases in [illegible] per cent of a material of 725 patients operated on with extended radical mastectomy including resection of the parasternal lymph nodes They noted only parasternal metastases with no involvement of the axilla in 8 per cent of the pa[illegible]nts

Submitted for publi[illegible]on 21 June 1973

Tabl 2

Data on 10 patients in group II

Age yrs	Sit of tumor	Size of tumor (cm)	Histology of tumor	Axill met
81	medial (right)	3 × 2 5 × 2	medullary ca	
59	lateral (right)	1 1 × 1	poorly diff ca	yes
49	central (Paget)	1 5 × 2 5 2	poorly diff adenoca	yes
70	lateral (left)	3 × 2 5 2	scirrhous ca	yes
91	central (right)	1 5 × 1 5 × 1 5	poorly diff denoca	yes
86	central (left)	4 × 2 5 × 3 5	poorly diff scirrhous ca	no
65	lateral (righ)	1 5 × 1 × 2	scirrhous ca	no
54	lateral (right)	3 5 × 3 5 × 3 5	poorly diff adenoca	yes
72	lateral (right)	1 1 5 × 2	ca with arying differentiation	yes
69	central (left)	2 5 3 × 3 5	poorly diff ca	yes

some time after injection of the colloid until transported to the gamma camera in a supine position The time elapsing between injection and th registration on the camera was 15 to 240 minutes (Table 1) the uptake then being followed for 30 to 60 minutes in two instances another examination was performed on the following day (17 hours after the injection) The activity in the abdomen was registered in 3 patients

The econd group (group II) consisted of 10 patients (Table 2) The ^{99}Tc S-colloid was concentrated to a volume of 1 ml with an activity of 500 μCi 200 IU hyaluronidase were dissolved in the colloid The colloid was in jected into the soft tissues, half on each side of the xiphoid process, after which the skin was massaged for a few seconds no local anaesthesia preceded the injection In 5 patients the colloid was injected exclusively intra and sub cutaneously while in the remaining 5 patients part of the colloid was injected deep into the oft tissues as well

The uptake in the parasternal lymphatics was followed 5 to 40 minutes after injection in one patient and the registration was repeated 16 hours later The remaining patients were registered 110 to 200 minutes after injection in 2 of these the examination was repeated 19 hours later and the registration carried out for 15 to 30 minutes

Table 1 (cont)

Remarks	Registration (after inj)	Findings at scintigraphy
–	30 – 60 min	Two left and one right lymph node
cholecystect	15 – 65 min	No nodes Diffuse filling of mediastinum
30 yr ago	17 hours	17 hours no nodes
	57 – 89 min	89 min no nodes 17 hours one right
	17 hours	diaphragmatic node
–	45 – 85 min	No nodes diffuse filling of mediastinum
–	3 – 70 min	No nodes diffuse filling of mediastinum
	100 – 150 min	T lymph nodes bilaterally and right supraclavicular fossa
–	30 – 60 min	No nodes Diffuse filling of mediastinum
cholecystect yrs ago	100 – 160 min	No nodes Diffuse filling of mediastinum
	240 – 270 min	Two left sided lymph nodes and two right diaphragmatic nodes

Indicates that part of the tracer substance was caught the site of injection

cording to PERSSON & NAVERSTEN (1970) The uptake in the parasternal lymph nodes was recorded on a gamma camera (Nuclear Chicago Pho/Gamma III) with a 4 000 channel or a pin hole collimator The collimator was placed as close to and as parallel to the sternum as possible the distance between the sternum and the collimator was usually not more than 7 cm The suprasternal notch and the xiphoid process were palpated and identified in all of the patients of both groups and these two points marked on the scintigraphy screen with a small radioactive source The intercostal spaces were palpated and the radioactive source was used to identify the levels of the lymph nodes on the screen

The first group (group I) consisted of 9 patients (Table 1) All the patients were examined in the following way the patient lay supine After careful cleaning of the skin of the abdomen to the left of the umbilicus 10 ml mepivacain (Carbocain 1 %) were injected in the subcutaneous tissues A needle was then inserted through the abdominal wall with the tip in the free peritoneal cavity The position of the tip was checked by fluoroscopy and the injection of a small amount of water soluble) radiopaque Ten ml ^{99}Tc^{m}S colloid with an activity of 500 μCi were injected into the free peritoneal cavity no drugs were added to the colloid The needle was rinsed with 10 ml saline and then withdrawn If the condition of the patient permitted she turned and lay prone for



Fig. 1. Parasternal scintigraphy with transabdominal technique. The suprasternal notch and the xiphoid process are marked by sharp dots. a) Two lymph nodes on the left side and one on the right side filled with tracer. b) Lymph nodes on both sides of the midline filled with tracer; a group of lymph nodes in the right supraclavicular fossa are also filled.

Discussion

Different methods have been published for the detection of lymph node metastases in the parasternal region. HANDLEY & THACKRAY (1949, 1954) described biopsy of these nodes. MASSOUD et coll. (1964) reported a series where tomography was performed in patients with induced pneumomediastinum. Transsternal phlebography is another possibility (CHERNOMORDIKOVA et coll. 1972). KETT et coll. (1970) described a method for direct lymphography of lymph vessels from the breast, but the method is not exclusively valid for the parasternal lymphatics.

Experimental investigations (CUNNINGHAM 1922, HELD 1932, SIMER 1944, COURTICE et coll. 1953, SALDEEN 1963, OLIN & SALDEEN 1964, GORANSON et coll. 1973) indicated that particles, macroproteins, blood corpuscles, thorotrast and ^{99m}Tc-S-colloid are absorbed from the peritoneal cavity through lymphatics in the diaphragm draining to the parasternal lymph vessels. The findings were confirmed in one human subject by ATKINS et coll. (1970) who discovered tracers in mediastinal lymph nodes following the injection of technetium colloid into the peritoneal cavity. The transabdominal method has not earlier been used for clinical evalution of the parasternal lymph nodes. The present results have proved that the technique is applicable in human subjects as well as in rabbits although this method has several disadvantages. One is the need of equipment for fluoro-

Tabl 2 (*cont*)

Registrat on after injection	Findings t scintigraphy
5–40 min	After 40 min no lymph nodes
16 h 15 min–16 h 30 min	After 16 hours four right and one left lymph node
130–150 min	One left and tw right lymph nodes
130–145 min	One lymph node in right pectoral group
1/0–18) m	Tw righ lymph nodes
130–14 m	No l mph nodes
108–145 min	Three right and w lef lymph nodes
180–900 min	
19 h 30 min–19 h 4 min	N lymph nodes
180–210 min	One lymph node on each side
180–19) min	Tw left lymph nodes
200–220 min	
19 h 20 min–19 h 3) min	Three right nd one left node

Results

Parasternal lymph nodes could be identified in 3 patients in group I (Table 1) In 2 of these the lymph nodes were observed on both sides of the sternum and in one in the supraclavicular fossa as well (Fig 1) while in the third patient 2 nodes were seen on the contralateral side of the carcinoma In the remaining 6 patients diffuse filling of radioactive colloid in the mediastinum was noted but no parasternal lymph nodes could be identified Right sided diaphragmatic lymph nodes (ROUVIERE 1932) were present in 2 patients In the 3 patients in whom the activity in th abdomen was registered a great part of the colloid injected had ac i ulat d at the ite of injection in 2 of these patients the parasternal lymp nod s were filled with tracer

Uptake in parasternal l mph nod s was present in 7 out of 10 patients of group II in 5 bilaterally Fi, 2 and in the remaining 2 patients unilaterally In one patient the uptake re tered in one lymph node considerably to the right of the sternum o esumably in the medial pectoralis group No lymph nodes were evident in the remaining ? patients

used but Tc* serum albumin has also been employed (SCHENK et coll 1966) The radiation dose locally absorbed is high when ¹⁹⁸Au is used for scintigraphy (HAUSER et coll 1969 HERTING et coll 1970) and radiation necrosis of the skin at the site of injection has been reported (HAAS et coll 1970) The physical properties of technetium are much more favourable than those of ¹⁹⁸Au its half life is only 6 hours and as there is no beta radiation the locally absorbed radiation dose is much lower

Experience in rabbits (GORANSSON & JONSSON 1974 a) suggested that the absorption from the site of injection to the parasternal lymph nodes should be observed within 30 minutes or less However the first patient examined with this technique failed to have any lymph node filling during 40 minutes after injection However a faint filling was noted after 16 hours The short half life of the tracer substance was thus of negative value The absorption was registered 2 to 3 hours after injection in the patients who followed this seemed to be the ideal time The repeat examinations in 2 patients at 19 hours produced no further information

The subcutaneous technique necessitates mixing the colloid with hyaluronidase to obtain maximal absorption in the parasternal lymph nodes (GORANSSON & JONSSON 1974 a) this is not required however with the transabdominal technique (GORANSSON et coll 1973) All patients of the present series have been verified with fine needle aspiration biopsy before the scintigraphy but according to experiments (GORANSSON & JONSSON 1974 b) such minor trauma of the thoracic wall does not affect the scintigraphy All patients, except 2 examined with the subcutaneous technique had radioactive tracer in parasternal lymph nodes indicating that the technique is more useful than the transabdominal one The interpretation of the scintigrams thus obtained is difficult The normal anatomic variations of the parasternal lymph nodes are considerable both in number and position (STIBBE 1918) An investigation with parasternal scintigraphy in 25 healthy subjects demonstrated these wide variations (MEYER BORG & WILHELMI 1971) lymph nodes most commonly appeared in the second or third intercostal spaces

The poor resolution in scintigrams permits no detailed examination of single lymph nodes as for instance in lymphography The only sign of metastases presented by lymph scintigraphy is blocking of the lymph flow and it has been claimed that non filling of a lymph node chain is proof of metastases Three patients of the present material had an uptake of tracer in unilateral parasternal lymph nodes The carcinomas of these patients were ipsilateral to the non filled side which may indicate parasternal metastases In the investigation of MEYER BORG & WILHELMI, however healthy subjects also had non filling of the parasternal lymph nodes in some cases

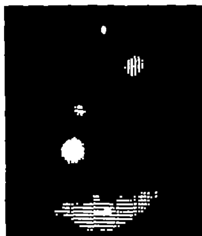


Fig 2 Parasternal scintigraphy with the subcutaneous technique The suprasternal notch and the xiphoid process marked by sharp dots T right and one left lymph nodes filled with tracer

scopy in order to ensure that the colloid is injected into the free peritoneal cavity Although this was carefully controlled the tracer failed appreciably to spread from the site of injection in at least 3 patients the omentum usually seemed to hinder the correct injection into the peritoneal cavity and the colloid was presumably trapped in the omentum However in 2 of the 3 patients, parasternal lymph nodes could be identified indicating that some tracer substance was injected into the free peritoneal cavity and was sufficient to be absorbed and outline parasternal lymph nodes

Another disadvantage with the transabdominal technique is that the patients who are mostly elderly cannot be moved about to improve the absorption it is of course easy to place a rabbit prone with the chest low Most of the patients in the present series were lying supine with the head and chest high because of cardiac failure or general weakness a position that obviously does not enhance the absorption Two of the patients in group I had been operated upon with cholecystectomy several years previously Neither had any filling of lymph nodes The *manner in which an abdominal operation affects the absorption* capacity of the diaphragm is not obvious therefore the injection must be even more carefully controlled because of the risk of adhesions secondary to the previous operation Our experience of the transabdominal technique is thus discouraging

The subcutaneous technique with injection of tracer on both sides of the xiphoid process or behind he process in the midline has been the method most often employed for the parasternal lymph nodes The technique has several advantages there is no need for fluoroscopy equipment and the position of the patient does not influence the examination Au colloid has been the substance most

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Another group difficult to interpret correctly is the one illustrated in Fig 1 a with filling of a lymph node in the 4th or 5th intercostal spaces, while the rest of the lymph node chain is not outlined The other type of scintigram with filling of one or 2 lymph nodes in the first or second intercostal spaces (Fig 2) suggests a normal lymph flow with no blocking The bilateral filling of lymph nodes (Fig 1 b) also indicates no blocking

These difficulties in interpretation emphasize the need for further investigations to determine the correlation between the scintigram and findings obtained at surgery with a technique of extended radical mastectomy as described by URBAN & MARJANI (1971)

Acknowledgement

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SUMMARY

Two techniques for parasternal scintigraphy with ^{99}Tc=S-colloid in carcinoma of the breast are described The first consists of the injection of the colloid into the free peritoneal cavity from where it is absorbed into the parasternal lymph vessels and nodes In the second technique the colloid is mixed with hyaluronidase and injected subcutaneously on both sides of the xiphoid process The technical aspects of these methods and the interpretation of parasternal scintigraphy are discussed

ZUSAMMENFASSUNG

Es werden zwei Verfahren zur parasternalen Szintigraphie mit ^{99}Tc= S Kolloid bei Karzinomen der Brust beschrieben Das erste besteht aus der Injektion des Kolloids frei in den Peritonealraum wovon es in den parasternalen Lymphgefassen und Knoten abgelagert wird Bei dem zweiten Verfahren wird das Kolloid mit Hyaluronidase gemischt und subkutan zu beiden Seiten des Processus xiphoideus injiziert Die technischen Aspekt dieser Verfahren und die Deutung der parasternalen Szintigraphie werden diskutiert

RÉSUMÉ

Description des deux techniques d scintigraphi parasternale par un lloid ^{99}Tc=S dans le cancer du sein I premiere consis dans l injection du colloid dans la grand cavite peritoneal d ou il est absorbe ers l aisseaux lymphatiques et les ganglions parasternaux Dans la se onde technique l colloide est melange d l hyaluronidase et inject *par voie souscutanee des deux cotes de l appendice xiphoide Les auteurs etudient* les aspects techniques de es methodes et l interpretation de la cintigraph parasternal

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AREA DISTORTION IN NARROW BEAM ROTATION RADIOGRAPHY

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In a panoramic image of the jaws produced with a rotating narrow beam there is no distortion at the centre of the object plane depicted without blurring: in this plane the magnification factor in horizontal and vertical directions is the same. Inversely, it may be maintained that the image is depicted without blurring in that very plane where there is no distortion, and this statement is valid irrespective of the projection radius of the object (SAMFORS & WELANDER 1974). However, outside the centre of the sharply depicted object plane different magnification factors are valid in the horizontal and vertical directions. The combined effect of the different horizontal and vertical dimensions in the panoramic image has been denominated as angle distortion (SAMFORS & WELANDER). Another effect arising from the same phenomenon is area distortion and has the result that the magnification factor of an area varies in the panoramic image: the magnification factor depends on the position of the area in relation to the centre of the object plane which is depicted without blurring and distortion.

Due to several factors which are specific to the rotating narrow beam methods the magnification factor of an area is not directly proportional to the distances

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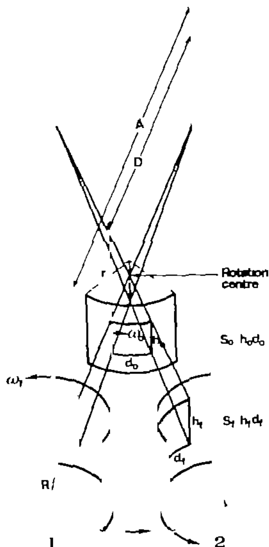


Fig 1 Schematic drawing of the exposure of an area S in curved object by means of rotating narrow beam and moving film Tw positions are represen ed bet een hich continuous move ment takes place when the object is exposed

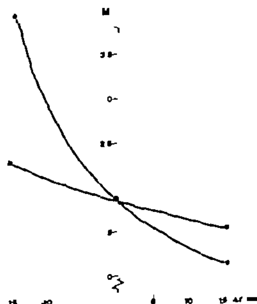


Fig. 2 The magnification factor of area as function of increment Δr of the object projection radius r. The functions are valid for the interior rotation centre r = 28 mm (●) and mean value of the projection radius in the lateral rotation centre r = 96 mm (■) in the Orthopantomograph 3. For object projection radii > 28 mm but < 96 mm the magnification factor varies continually in the interval between the illustrated functions. The functions intersect the plane in the object which is depicted without blurring and distortion; area distortion occurs outside this plane.

$$d_t = \frac{d_o R \omega_t}{(r + \Delta r)\,\omega_o} \tag{1}$$

$$h_t = \frac{h_o A}{D + \Delta r} \tag{2}$$

An area in the object S_t is depicted in the image as $d_t h_t$. From equations (1) and (2) the following is thus obtained

$$S_t = \frac{h_o d_o A R \omega_t}{(D + \Delta r)\ (r + \Delta r)\omega_o} \tag{3}$$

In rotating narrow beam methods one plane in the object is depicted without blurring and this occurs when

$$\frac{R\omega_t}{r\omega_o} = \frac{A}{D}$$

From equation (3) a simplified expression is therefore obtained by substitution

$$S_t = \frac{h_o d_o A\ r}{D(D + \Delta r)\ (r + \Delta r)} \tag{4}$$

$h_o d_o$ is the area in the object S_o. An expression for the magnification factor may thus be obtained from equation (4)

$$M = \frac{S_t}{S_o} = \frac{A^2 r}{D(D + \Delta r)\ (r + \Delta r)} \tag{5}$$

focus to object and focus to film as in an ordinary central projection It was therefore considered of interest to calculate the area distortion in narrow beam methods which does not seem to have been analysed mathematically previously

The mathematical expressions were deduced using the model for narrow beam rotation methods presented by WELANDER (1974)

Area distortion

Definitions (See Fig 1)

h_o = vertical distance in the object
h_f = length of the distance h_o projected on the film
d_o = horizontal distance in the object
d_f = length of the distance d_o projected on the film
S_o = area in the object, $h_o d_o$
S_f = size of the area S_o projected on the film $h_f d_f$
M_a = magnification factor S_f/S_o
r = distance from rotation centre of the beam to the centre of the object plane depicted without blurring 'object projection radius
R = film radius
ω_o = angular velocity of the beam in the object
ω_f = angular velocity of the film
D = distance tube target to object
A = distance tube target to film

Deduction In the horizontal plane the length in the image of a distance in the object is

$$d_f = \frac{d_o R \omega_f}{r \omega_o}$$

and in the vertical plane the length in the image of a distance in the object is

$$h_f = \frac{h_o A}{D}$$

If the distance from the rotation centre of the beam to the centre of the object plane which is depicted without blurring r is given an increment Δr the distance between the tube target and the object D receives the same increment Thus when the object position differs from the object projection radius the following distances are valid in the horizontal and vertical planes respectively

projection radius However the factor varies when an area in the object does not coincide with the plane depicted without distortion and blurring When the object projection radius is given a positive increment, that is when the object is positioned in front of the distortion free plane, the magnification factor decreases when the object projection radius is given a negative increment that is when the object is positioned behind the distortion free plane, the factor increases The variation of the magnification factor is most marked when the object projection radius is small For example, in the frontal rotation centre of the Orthopantomograph 3 the magnification factor will increase by more than 20 per cent when an area is displaced 5 mm behind the distortion free plane and it will decrease by more than 15 per cent when the area is displaced 5 mm in front of the distortion free plane The figures valid for the lateral rotation centre are markedly smaller about 5 per cent in both cases

The fact that the magnification factor of an area varies depending on its position in relation to the object projection radius in rotating narrow beam methods depends on different horizontal and vertical length dimensions in the image The conclusion must be that assessments of both the morphology and the size of structural details of the object must be made with some caution in a panoramic image especially in the frontal region but to a certain degree also in the lateral regions (Fig 3) However together with distortion phenomena, blurring of the image occurs when the object does not coincide with the object projection radius To a certain extent the blurring may be used to indicate the reliability of the image with respect to distortion but it should be observed that there is a zone on both sides of the sharply depicted and distortion free object plane where the blurring of the image is negligible but where the distortion phenomena are evident

SUMMARY

An image exposed with rotating narrow beam methods is free from distortion at the centre of the object plane which is depicted without blurring Outside this object plane the magnification factor is different in the horizontal and vertical directions causing distortion of the image and variable magnification factor of an area The variation of this magnification factor in this report called area distortion has been calculated mathematically From the mathematical expressions functions have been obtained which are valid for the Orthopantomograph 3

ZUSAMMENFASSUNG

Ein mit den Methoden eines engen rotierenden Strahls exponiertes Bild ist im Zentrum der Objektebene die ohne Undeutlichkeit abgebildet wird frei von Distortion Ausserhalb dieser Objektebene ist der Vergrösserungsfaktor in der horizontalen und vertikalen Richtung unterschiedlich wodurch eine Distortion des Bildes und eine betrachtlicher Vergrösserungs

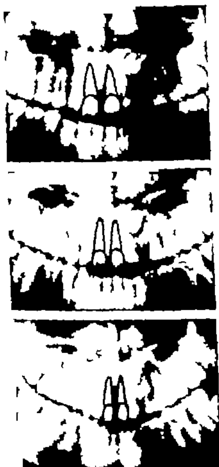


Fig 3 The size of the teeth varies with the position of the object — area distortion. Object position towards the rotation centre (top), correct position (middle) and towards the film (bottom)

From equation (5) the variation of the magnification of an area, the area distortion in rotating narrow beam methods may be calculated. With the values for the object projection radii and for the target to object and target to film distances that apply in the Orthopantomograph 3 the functions illustrated in Fig 2 will be obtained

Discussion

The magnification factor of an area which coincides with the object plane depicted without blurring is 1 8 in the Orthopantomograph 3. This is the square of the magnification factor of the horizontal and vertical dimensions in the object plane. The magnification factor is independent of the object

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COMBINED THERMOGRAPHY AND ISOTOPE SCANNING IN THYROID PATHOLOGY

G. GALLI, D. SALVO, L. TRONCONE and G. DE ROSSI

The thyroid gland is considered an ideal organ for thermographic examination both because of its superficial position and its rich vascularization. It is therefore surprising that so few have been interested in this field and that results obtained have been contradictory. Both GROS et coll. (1961, 1968) and VAUBEL were pessimistic, pointing out the unreliable results and the difficulty of interpretation. The neck configuration and the superficiality of its larger vessels are limiting factors.

On the other hand, HEERMA VAN VOSS (1966) and SAMUELS (1972) had a more positive attitude. The latter has described 50 cases, mentioning an 85 to 95 per cent positive correlation between thyroid diseases and thermographic results and stressing the value of the method in the differential diagnosis of cold nodules revealed in thyroid scans.

The present work is a report on 125 thyroid examinations in which an apparatus obtaining simultaneously a thermogram and an isotope scan was used.

Method. Recordings were carried out with an accessory (MT-4 Magnatherm) connected to the collimator of the scanner (Fig. 1). The Magnatherm consists

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faktor eines Gebietes hervorgerufen wird Die Schwankung dieses Vergrosserungsfaktors die in diesem Bericht Distorsion des Gebietes benannt wird wurde mathematisch berechnet Aus diesen mathematischen Ausdrucken wurden Funktionen erhalten die fur den Orthopantomograph 3 Gultigkeit haben

RÉSUMÉ

Une image prise par des méthodes utilisa t des faisceaux étroits tournants n a pas de distorsion au centre du plan objet qui est représenté sans flou Hors d ce plan objet le facteur d agrandissement est différent dans les directions horizontales et verticales donnant lieu une distorsion de l image et un facteur d agrandissement ariable pour une surface La variation de ce facteur d agrandissement ppelée dans ce tra ail distorsion de surface été calculée mathématiquement Les expressions mathématiques ont permis d obtenir des fonctions qui sont alables pour l Orthopantomographe 3

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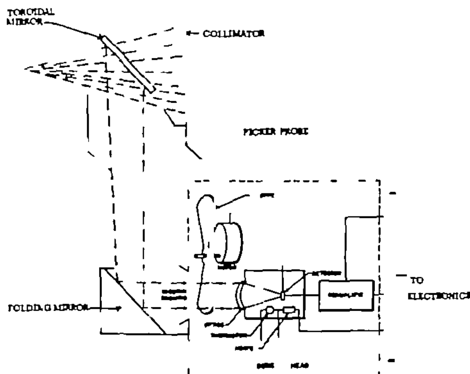


Fig Diagram of the MT 4 Magnatherm optical system

vealed by thermography A difference in temperature exceeding 1 5 to 2 C in a hyperthyroid patient was sometimes observed

Wider experience should make it possible to obtain statistical correlations between increased temperature values and values for thyroid function tests There is no doubt however that a thermogram can better establish and confirm the raised temperature in prethyroid skin already well appreciated by the clinician in case of advanced exophthalmic goiter

Hypothyroidism In hypothyroidism the thyroid cannot be seen in the thermographic image obtained with a Magnatherm

Thermography proved valuable in cases of pharmacologic interference after administration of iodine compounds, such as contrast media With unaltered thyroid function the thermography was normal while the [1] I uptake and scan simulated hypothyroidism

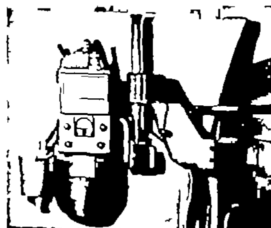


Fig 1 The Magnatherm connected to the scanner collimator

of a thermistor bolometer which receives infrared radiations through mirrors and is also connected to the scanner electronic system (Fig 2)

Cutaneous temperature is recorded both in centigrades and in Fahrenheit degrees the apparatus can be set for three different levels of sensitivity according to the difference between cold and hot areas The corresponding temperature gap is moreover divided into a range of eight different colours from red (hotter areas) to white (colder areas) With a gap of 2 to 4 C the change in colour in the image would then mark differences in cutaneous temperature of about 0 3 C

Fifteen minutes are allowed for the skin to equilibrate with the environment in a controlled ambient temperature of 20 C before recording which takes five minutes

Results

Normal thyroid In thermography with a Magnatherm the thyroid is represented as an area of slightly increased temperature (never superior to 1 to 1 5 C) with unsharp borders inscribed in a relatively cold area corresponding to the trachea and larynx

The thermographic image of the thyroid is sometimes hard to identify due either to the presence of rich subcutaneous fat or to a short thick neck In such cases the thyroid could be easily confused with other hot areas such as the sternum region the great vessels the jugular and the supraclavicular fossa

Hyperthyroidism Increased metabolism and greater vascularization observed in hyperthyroidism may give an increased cutaneous temperature which is re

cutaneous temperature. The values were close to those recorded for hyperthyroidism and toxic adenoma. This relationship seems logical in view of the proliferative activity and the increased vascularization of a neoplastic disease. In contrast to Plummer adenoma, areas of reduced or low activity were obtained on isotope scanning.

Thermography gave equivocal results in benign tumours. Only three adenomas with no toxic characteristics were examined.

Discussion

The observations suggest the value of combined thermography and scanning mainly in the diagnosing of thyroid nodules.

With hyperfunctioning adenomas, well diagnosed by clinical and isotope tests, thermography could prove of minor importance, while being of great usefulness in distinguishing 'cold' areas on the scan due either to cysts or to benign substitutive processes from those due to malignant tumours. The cutaneous temperature is unaltered or lowered in benign growths while a definite increase in skin temperature is observed in malignant tumours.

The use of the Magnatherm could present valuable possibilities for analyzing and localizing even small growths. Thermography and isotope scan fit perfectly as they are carried out at the same time and with identical conditions and position of the patient.

A few limitations of thyroid thermography need to be considered however. Nodules of less than 2 cm may give no appreciable changes in a thermogram. Even lesions larger than this could hardly be seen when situated in marginal areas covered by the sternocleidomastoid muscles or close to the great vessels of the neck. If the thyroid is large, lesions close to or below the thoracic inlet may *not be seen*.

It should also be borne in mind that benign lesions give equivocal thermograms and the same could happen with poorly vascularized malignant tumours.

These limitations do not in our opinion affect the validity of the method but they emphasize the necessity of accuracy in evaluating results. Thermography is likely to become an essential aid in the diagnosis of thyroid lesions.

SUMMARY

A Magnatherm Picker apparatus permitting simultaneous thermography and isotope scanning has been used for examination of the thyroid. Thermography was of value in the diagnosis of functional alterations. Hyperthyroidism causes an increase of cutaneous temperature. Combined thermography and isotope scanning appeared useful for investigating non-active thyroid nodules while malignant tumours tend to increase cutaneous temperature; cysts could give rise to areas of relative hypothermia. An increase in temperature was also seen in [illegible] active toxic adenoma.

Table

Thermography in 31 patients operated upon for extra thyroid se tary nodules

Skin temp ture	Histology	No of cases
+	Toxic adenoma	5
	Carcinoma	6
	Follicular 1	
	Papillary 3	
	Indifferen 2	
	Benign adenoma	1
±	B nign denoma	1
	Regional hyperplasia	1
−	B nign adenoma	1
	Toxic adenoma	1
	Cysts	1

Thyroid nodules The results are based on 31 patients who underwent opera t on (Table) The upper part of the Table refers to cases with increa ed cu taneous temperature (+) over the nodular formation and the lower part to tho e with a normal or relatively hypothermic thermogram (—) The middle part cons sts of two cases with a doubtful thermogram

Plummer adenomas Out of 10 cases only 2 according to GROSS & VROUBOS (1966) gave a typical image with the o called localized area of increased cutaneous temperature Seven patients had a normal temperature and one diffuse hypothermia

Our results on the other hand indicated increased temperature slightly wider than the corresponding nodule in 5 out of 6 toxic adenomas The sixth ca e had no alterations in cutaneous temperature but histologi examination presented a vast zone of necrosis following hemorrhage

Cysts At operation 15 patients had c sts in the area corresponding to nodules In every case the can had area of ab ent uptake and the thermogram areas of decreased cutaneous temperature

In small cysts the decreased temperat re was confined to the cutaneous area corresponding to the nod ile while in he oluminous ones the hypothermia in cluded besides the c al o the skin cove ing the remaining thyroid parench ma

Tumours Six ca es of histologically confirmed malignant tumours were ther mographically tes ed The thermogram demonstrated an evidently increased

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NORMAL LYMPHOGRAPHIC VARIATIONS OF LUMBAR, ILIAC AND INGUINAL LYMPH VESSELS

ALF KOLBENSTVEDT

Obstruction of lymph vessels with collateral by-passing is a valuable sign in the diagnosis of metastases in the lymphatic system (HAHN et coll. 1963, FUCHS et coll. 1964, 1968, FUCHS 1972, FRISCHBIER 1966, 1972). Large totally infiltrated lymph nodes have, however, also been reported without concomitant alteration of the lymph flow (JACKSON 1967). Knowledge of the normal anatomic variations is a prerequisite for a satisfactory evaluation of collaterals. Although the lymph vessel system is subject to innumerable variations (FUCHS et coll. 1968), probably unsurpassed by any other organ system (HUTH 1972), some principles may be discerned.

While the normal and pathologic variations in the lymphographic appearance of the cisterna chyli and thoracic duct have been thoroughly elucidated (WEISSLEDER 1964, WALLACE & JACKSON 1968, RAGLONO & COSSU 1969, WIRTH & FROMMHOLD 1970, FUCHS & GALEAZZI 1970, JACOBSSON 1972), less attention has been given to variations in the peripheral lymphatic trunks.

Material. During the period February 1970 to March 1973 preoperative lymphography was performed in 300 consecutive patients with carcinoma of the uterine cervix stages Ib and II. The treatment consisted of radical hysterectomy

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ZUSAMMENFASSUNG

Ein Magnatherm Picker Apparat der di gleichzeitige Thermographie und Isotopen Scanning erlaubt wurde zur Untersuchung der Thyreoidea ver endet D e Thermographi ar zur Diagnose von funktionellen Veranderungen von Wert H perthyreo dismus hatte den Anstieg der Hauttemperat zur Folge Die mit der Thermographie kombiniert Iso topen Scanning erschien bei der Untersuchung nicht aktiver Knoten der Thy eoidea nutz lich ahrend mal gne Tumoren zu einer gesteigerten Haut Temperat f hrten fuhrten Cysten zu Geb eten relativer Hypothermie Eine gesteigerte Temperatur r ebenfalls bei [1]I aktiven toxischen Adenomen zu sehen

RÉSUMÉ

Un appareil Magnatherm Picker permettant sim ltanement la thermographie et la scint graphie isotopique a et utilise pour l examen de la thyroide La thermographie present un interet pour le diagnostic des alterations fonctionnelles L hyperthyroidi m cause un augmentation de la temperature cutanee L as ociation d la thermographie et de la cint graphie isotopiqu para t tile pour l examen des nodules thyroidiens inactif lors qu les tumeurs malignes tendent à augmenter la temperature cutanee les ky tes pourraient donner lieu des surfaces de relative hypothermie Une augmentation de la temperature et con tatee aussi dans des adenomes toxiques fixant [1]I

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Fig 1



Fig 2



Fig 3



Fig 4



Fig



Fig 6

(For legend see opposite page)

and pelvic lymphadenectomy 6 weeks after radium insertions An average of 30 6 lymph nodes per patient were removed and examined histologically The present investigation was based on the first 200 patients without lymph node metastases A detailed description of the lymphographic methods used and the surgical procedure has been given by KOLBENSTVEDT & KNUDSEN (1974) and KOLBENSTVEDT & KOLSTAD (1974)

Results

Iliac lymph vessels The external iliac lymphatics are divided into three chains according to the classic descriptions by CUNEO & MARCILLE (1901) and ROUVIERE (1932) they run on either side of and between the external iliac artery and vein The names lateral intermediate and medial chains were recommended at the International Symposium of Lymphology Zurich 1966 At lymphography three main stems may be demonstrated (Fig 1) but more often the vessels have an unsystematic, disordered appearance where the main trunks cannot be discerned In the present material three main lymphatic trunks appeared in 41 per cent on the right side and in 37 per cent on the left CHAVANNE et coll (1967) reported a corresponding 35 per cent in 100 lymphographies

Lymph vessels within the internal iliac regions (Figs 2 5) were demonstrated in 56 per cent on the right side and in 53 per cent on the left These vessels sometimes proceeded posteriorly towards the lower part of the sacrum

By-passes All lymph nodes filled by injection into a lymph vessel in the foot from the inguinal region to the lumbar region may be by passed An inguinal by pass (Fig 3) has previously been described by FRISCHBIER (1966) and KINMONTH (1972) The former noted that such a lymph vessel usually ended in the most distally situated lateral external iliac node — the lateral lacunar node This node has also been called the semilunar node, the appearance being due to fibrolipomatous infiltration The inguinal nodes, being the primary filter stations often have similar appearances The lateral lacunar node may thus often functionally be regarded as an inguinal nod due to by passing although anatomically belonging to th iliac group

External iliac by passes (Figs 4 5) were observed in 7 patients (3 5 per cent) The e ves els as a rule passed by the external iliac and the lower part of the common iliac region to some small lymph nodes along the iliac crest They have been denominated lumbar vessel (FUCHS et coll 1968) and chaine circonflexe iliaque (ROUVIERE 1932)

Common iliac by passes (Figs 6 7) were observed twice In both instances lymph vessels along the p oas major muscle passed by the common iliac region to lymph nodes on the dorsal and lateral surface of the psoas



Fig 9a Fig 9b Fig 10

Fig 9 a) Right lateral inguinal loop b) Left lateral inguinal loop No filling of lateral inguinal lymph nodes in the loops

Fig 10 Intercostal loop in the 10th right intercostal space

space (Fig 10) and once in the 9th left intercostal space In the latter case a small chain of intercostal lymph nodes was demonstrated The thoracic duct was not obstructed

A subpubic loop was revealed once (Fig 11) This loop just extended across the midline inferior to the symphysis pubis and led to filling of a right obturator lymph node ARVAY & PICARD (1963) described a normal but exceptional lymph vessel crossing the midline along the pubic bones but superior to the symphysis pubis (voie anastomotique sus pubienne)

Lymph vessels in connection with the obturator node The French anatomists CUNEO & MARCILLE (1901) and ROUVIERE (1932) denominated the lymph nodes between the external iliac vessels and the obturator artery and nerve the medial or internal chain of the external iliac lymph nodes The name obturator node is reserved for one or a few nodes along the peripheral branches of the obturator artery close to the obturator foramen This node was only demonstrated in 5 patients (2.5 per cent) Unusual lymph vessels occurred in three of them (Figs 11 12 13) in one case (Fig 13) as a perivesical lymphatic

Presacral anastomoses The lateral sacral lymph nodes were demonstrated in 41 per cent of the patients but transverse presacral anastomoses (Fig 14) were only observed in 6 patients (3 per cent)

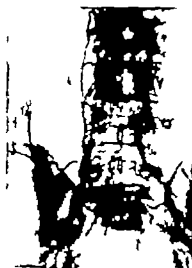


Fig 7



Fig 7b

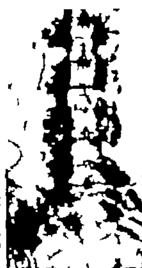


Fig 8

Fig 7) Right common iliac d lumbar b pass b) A chain f lymph nodes long the la eral surface of the psoas major is filled

Fig 8 U usually long right lumbar by pass A larger number of lymph nodes demonstrated in the left than in the right lumbar region

A right lumbar by pass (Fig 8) was reported by WIRTH (1966) and KIN MONTH (1972) The latter reported a corresponding discontinuity — the right lower lumbar gap — in the ch un of lymph nodes Thus the right lumbar region may be defectively demonstrated following injection into a foot lymphatic the con equence being that the lymphography often has to be supplemented by phlebography of the inferior vena ca a and urography

Blind loops Lateral inguinal loops were observed in two patients (Fig 9) No lymph nodes were filled through these loops and no signs of lymphatic obstruction were present Thus no reasonable explanation of the finding can be given

Intercostal loops were also observed twice once in the 10th right intercostal

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Fig 1 The three normal ilia lymph essel trunk late al ermedia and medial

Fig Lymph essels to the ternal ilia lymph nodes The essels eem encircl an primary lesion but no bnormal ties were found t operatic

Fig 3 Inguinal by pass (→) The contrast med m flo d rectly to the most caudal lateral external iliac node (tl la eral lacunar node)

Fig 4 External iliac by p or circumflex iliac bra h usually by pa sing the external iliac and the most caudal common iliac lymph odes Note long the iliac crest re often f lled in this essel

Fig 5 Right iliac region N merous in ernal lia l mph essels and an external iliac by pass

Fig 6 Left comm il ac by pa w th ly ph h and node t the psoas major muscle

Conclusion

The normal anatomic variations of the lymph vessels are numerous, and may appear as by passes blind loops, vessels to the obturator node or prevertebral anastomoses. Knowledge of these variations is necessary to avoid false diagnoses.

SUMMARY

Some lymphographic variation of the lumbar iliac and inguinal lymph vessels based on normal material of 200 cases are described.

ZUSAMMENFASSUNG

Einige anatomische Variationen des inguinalen und Becken-Lymphsystems bei einem Material von 200 Fällen werden beschrieben.

RÉSUMÉ

Description de quelques variations lymphographiques des vaisseaux lymphatiques lombaires iliaques et inguinaux basée sur une série de 200 cas normaux.

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Fig 11 Right obturator lymph node (→) filled in subpubic loop extending across the midline inferior to the symphysis pubis



Fig 1 Right obturator lymph node close to the anterior abdominal wall filled in lymph vessel from the contralateral side

Lymph vessel displacement and pathologic lymphatics Tortuous arteries often displace lumbar and iliac lymph nodes and vessels (WIRTH 1966 FUCHS et coll 1968) These displacements may have an appearance similar to that caused by tumours thus giving rise to differential diagnostic difficulties

In patients with obstruction of the lymphatic flow a variety of lymph vessels have been described as collaterals In the present normal material the following vessels were never encountered dermal backflow (KINMONTH et coll 1962) uterine or rectal collaterals (FUCHS et coll 1968) mesenteric splenic or hepatic collaterals (CUNNINGHAM 1969 MARKOVITS & BERGIRON 1970) perineural sheath collaterals (WALLACE et coll 1964) abdominal wall collaterals to the axillary region (HARTGILL 1964) This supports the suggestion that all these collaterals have a pathologic significance Trapping of oil droplets in veins through lymphovenous anastomoses (KINMONTH 1972) was never observed

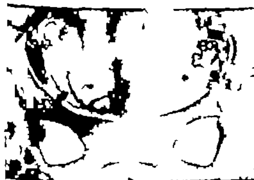


Fig 13 Perivesica lymph vessel and right obturator lymph node (→)

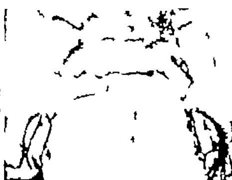


Fig 14 Left lateral sacral lymph node filled in presacral anastomosis

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APPEARANCE AND GROWTH OF EARLY CARCINOMAS OF THE COLON-RECTUM

G. EKELUND, C. LINDSTRÖM and J. E. ROSENGREN

Polyps even with a diameter of less than 5 mm may be demonstrated by means of double contrast radiography of the large bowel (ANDRÉN et coll. 1955). This gave rise to the practical problem of distinguishing small benign polypoid tumours from malignant ones, but WELIN et coll. (1963), TROELL et coll. (1965) and WELIN (1967) reported some radiographic features indicating malignancy of such small lesions.

The intention of the present investigation was to examine in retrospect a series of patients with carcinoma of the colon-rectum for preceding signs of polypoid lesions at the site where a carcinoma had later been diagnosed and to analyse the radiographic features of any such early lesion. This was possible because a recent investigation of 960 cases of carcinomas of the colon-rectum (BERGE et coll. 1973) included a group of patients who had been examined on several occasions with double contrast radiography of the colon for several years before operation.

The intention was also to investigate the growth rate of tumours and the effect of delaying operation as judged from histologic stages of tumours, frequency of metastases and survival rate.

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G. Ekelund, C. Lindström and J. E. Rosengren

Polyps even with a diameter of less than 5 mm may be demonstrated by means of double contrast radiography of the large bowel (Andrén et coll. 1955). This gave rise to the practical problem of distinguishing small benign polypoid tumours from malignant ones, but Welin et coll. (1963), Fiorel et coll. (1965) and Welin (1967) reported some radiographic features indicating malignancy of such small lesions.

The intention of the present investigation was to examine, in retrospect, a series of patients with carcinoma of the colon-rectum for preceding signs of polypoid lesions at the site where a carcinoma had later been diagnosed and to analyse the radiographic features of any such early lesion. This was possible because a recent investigation of 960 cases of carcinomas of the colon-rectum (Berge et coll. 1973) included a group of patients who had been examined on several occasions with double contrast radiography of the colon for several years before operation.

The intention was also to investigate the growth rate of tumours and the effect of delaying operation as judged from histologic stages of tumours, frequency of metastases and survival rate.

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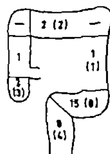


Fig 1 Location of the 30 tumours F gures w thin brackets indicat location of tumours overlooked t first examination

Material and Methods The 960 cases of carcinoma of the colon rectum con titute 94 per cent of all ca es diagnosed during life in the city of Malmo during 1958 to 1967 and treated at the Department of Surgery of Malmo Allmanna Sjukhus the only one in the city (BERGE et coll 1973) In this series where the double contrast method had been used routinely for examinations of the colon there were altogether 30 cases in which the diagnosis of carcinoma had been preceded by local abnormalities indicating a small polypoid tumour (6—26 mm in diameter) These patients 22 men and 8 women with a mean age of 66 years constitute the present material In all of these 30 patients the colon rectum had been examined with the double contrast method 2 to 10 times on the average 3 times before operation All films were examined for the signs described as characteristic of malignancy (WELIN 1967 the Table) Growth rates were as sed from measurements of the largest diameter of the polyps measured on roentgenograms taken in the same projection Histologic specimens from all cases were reviewed The tumours were staged according to DUKES (1932) and the carcinomas were graded as being well moderately or poorly differentiated

Results

Small haemorrhages (12 cases) were usually the indication for the roentgen examination of the colon

Tabl

Number of polypoid lesions w th carcinoma en ms t first examination

Mo than 10 mm diameter	21
Irregula surface of the tumour	17
Ba he ght	9
Inden on b se	6
N th signs	4



b

Fig. 4. Woman aged 5 examined because of rectal bleeding.) A 9 mm × 9 mm pedunculated polyp with irregular surface in the sigmoid colon. b) Fi months later slight increa in size. c) After another 5 months 13 mm × 17 mm. Histology: Moderately to poorly differentiated adenocarcinoma with invasion through the muscularis mucosae. N signs of a recurrenc 156 months after operation.

Histology of the operative specimens revealed that all the tumours were carcinoma. Seven were still polypoid, 11 medallion-shaped and 12 annular. (One tumour was not operable and the diagnosis is based on autopsy instead.) In 2 cases the carcinoma was confined to the lamina propria, in the other 28 it had invaded at least the muscularis mucosae. Nine patients were classified as A-cases (DUKES 1932) (tumour spread into the tissues of the bowel wall but not beyond the muscularis propria), 10 as B (tumour grown through the muscularis propria but not spread to lymph nodes), 8 as C (metastases in regional lymph nodes) and 3 cases had distant metastases. Of the 28 patients operated upon for cure, 13 later had developed distant metastases (on the average 30 months after operation).

Altogether 19 (63 %) of the 30 patients were found to have metastases either at operation or at a later examination. Distant metastases were later found in 4 of the 7 cases classified at operation as belonging to group A. These 4 tumours were moderately or moderately to poorly differentiated. In one case the tumour was excised locally but it is doubtful whether the operation was radical.

The 5-year survival rate after operation was 57 per cent in the total material, in A-cases 89 per cent, in B-cases 60 per cent and in C-cases 50 per cent.

No correlation seemed to exist between the stage of the tumour at operation and the rate of growth or the duration of the observation time. The material is too small to permit statistical conclusions.

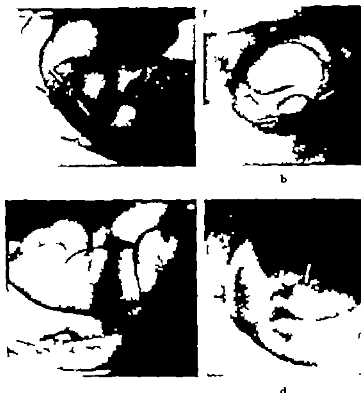


Fig 3 Man aged 68 examined because of rectal bleeding a) An 8 mm × 8 mm polyp of the sigmoid colon without signs of malignancy overlooked b) Nine months later 12 mm × 15 mm. c) After another 16 months 15 mm × 15 mm outline then irregular d) Sixty four months after the initial examination 18 mm × 21 mm Histology A polypoid moderately differentiated adenocarcinoma growing through the muscularis mucosae Eighty-eight months later the patient died Autopsy Primary liver cell carcinoma no metastases from the carcinoma of the colon

such characteristic indentation including one case where the polyp was less than 10 mm across

None of these signs was present in 4 of the patients at the first examination (Fig 3)

Growth rate During the observation period all tumours increased in size Fig 2 reveals the size of each primary polypoid lesion and of the corresponding final carcinoma (in the last preoperative film) The mean linear diametric growth was 0 61 mm per month (range 0 06—2 00 median 0 52) The smallest carcinoma in this series was 13 mm × 17 mm at operation (Fig 4)

a b

Fig. [illegible]

lesions than in benign ones (WELIN 1967). These signs are not unconditionally pathognomonic of malignancy. In the present series only carcinomas were included and the early appearance of the reported signs of malignancy, on an average 3 years before operation, analysed; the signs will be discussed briefly.

Size. The risk of a polypoid tumour being malignant rapidly increases when it is more than 10 to 12 mm in diameter (SPRATT & ACKERMAN 1960, ENTERLINE et coll. 1962, WENCKERT 1965). In the present series a diameter of more than 10 mm was also the most common finding in the first films (Fig. 6). All tumours were more than 10 mm across when removed. FIGIEL et coll. (1965) could not trace a single report of a carcinoma that had been antedated by dem-



Fig 5 Man aged 49 examined because of constipation) A rectal polyp 8 mm × 9 mm about characteristics of malignancy overlooked b) Eighty four months later tumour 7 mm × 79 mm Histology Moderately to poorly differentiated adenocarcinoma ith invasion of the muscularis propria Eight years later perineal recurrence

Discussion

The diagnostic value of roentgenographic signs believed to indicate malignancy depends on how often also benign lesions have such features This question is still open A long term prospective observation of patients with a random selection of various polypoid lesions of the colon rectum, not subjected to excision until late, would probably be valuable in this respect, but since this cannot be performed in man the problem can be approached only by retrospective analyses

The radiologic abnormalities de cribed as signs of malignancy and which have been u ed in the present material are encountered more often in malignant

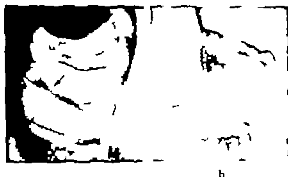


Fig 6 Woma aged 79 examined because of constipation) A 10 mm × 14 mm polyp of the sigmoid colon without signs of malignancy overlooked b) Twenty tw months later an nnular tumour 40 mm in diameter t th site of th previous polyp Histology Moderately differentia ed nnula denoca cinoma growing through the bow l all th lymph node metastases Recurrence 8 months later after another 3 months the patient died Autopsy Hepatic metastases

Growth rate. The most reliable sign of malignancy, however, seems to be an increase in size. On the basis of over 300 cases of polypoid tumours of the colon Hotel et coll. (1965) concluded that the assessed growth rate can be utilized in deciding whether a polyp is benign or malignant. Welin et coll. (1963) analysed the growth rate in serial films of 375 tumours of different morphologic types and reported that polyps that grew fast were more often malignant than the others. Most benign and unremoved polyps did not increase in size. Welin et coll. found carcinomas to have a linear diametric growth rate of 0.09 to 0.75 mm per month (median 0.24 mm). In the present series the corresponding figures were 0.06 to [illegible].00 mm per month (median 0.52 mm). The tumours varied somewhat in growth rate (Fig. [illegible]) but no correlation seems to exist between the growth rate and the stage of the tumour at operation.

For correct assessment of growth rate as well as of roentgenographic features of malignancy it is imperative that the bowel be perfectly clean to permit detection and demonstration of the morphology of small lesions. It is probable that 6 of the present cases were overlooked because of unsatisfactory cleaning of the bowel.

Histology [illegible] tumours revealed that in spite of the long (average 5 years) preoperative [illegible] period 30 per cent were in group A (Dukes 193[illegible]) when removed and the overall 5 year survival rate was as high as 57 per cent. These findings [illegible] that the natural history of at least some carcinomas of the colon [illegible] long. Nevertheless, even small polypoid lesions with roentgenographic appearance of malignancy indicate surgery in order to forestall metastases since in [illegible] of the present cases, not operated upon until a [illegible] period after the appearance of such polyps, metastases were found at the operation or later.

Conclusion. Tumours with roentgenographic appearance of malignancy should be removed as soon as possible. In the absence of malignant sign careful observation with repeated roentgenography is imperative.

SUMMARY

Thirt[illegible] patients [illegible] for carcinoma of the colon rectum which had [illegible] could be shown in retro[illegible] grow[illegible] from small polypoid tumours were analysed. Repeated double contrast roentgenography [illegible] performed before the operation during a mean observation time of 5 years. When first demonstrated all but 4 of the polypoid tumours had at least one roentgenographic sign of malignancy. The mean linear diametric growth rate was 0.[illegible] mm/month. The 5 [illegible] was 57 per cent. Metastases were found in 19 cases.

ZUSAMMENFASSUNG

Drei[illegible] wegen eines Colon-Rect[illegible] Carcinoms behandelte Patienten, welches wie retrospektiv gezeigt werden konnte von kleinen polypoiden Tumoren aus gewachsen war, wurden analysiert. Wiederholte Doppelkontrast-Röntgenuntersuchungen waren [illegible] der Operation



Fig 8 Same case as in Fig 7 One year after biopsy the tumour measured 8 mm × 24 mm b) After another years 20 mm × 69 mm Abdomino-perineal amputation of the rectum Histology Moderately to poorly differentiated adenocarcinoma growing through the rectal wall no metastases in the regional lymph nodes no benign remnant The patient survived the operation 108 months Autopsy No signs of recurrence

b

onstration of a local polypoid tumour less than 10 mm across by more than 2 years The present series however included one such example (Fig 4) In this series almost one third of the polyps which were later removed as carcinomas were originally smaller than 10 mm in diameter It is therefore important that also the other signs must be carefully looked for in small polyps

Irregular surface WELIN (1967) found that carcinomas have a rough cauliflower like surface instead of a smooth surface statistically more often than benign lesions In the present series the second most common roentgenographic sign of malignancy of the original polypoid lesion was an irregular outline It occurred in more than half of the cases at the first examination and in all the other cases during the observation period (Figs 5 7 8)

Base Sessile polyps are often regarded as being more apt to be malignant than are pedunculated polyps WELIN (1967) found that sessile polyps with a broad base i e by definition polyps where the base of the polyp in the profile view exceeds the height of it, were more likely to be malignant than benign Using the same criterion for a broad based polyp as WELIN (1967) it was found that 9 of the polyps in the present series were broad based In films from the last roentgen examination all but 6 were broad based This sign seems to be valuable though it is probably less often encountered if the polyp is very small

Indentation of the bowel wall was seen at the first examination in only 6 of the present cases This might be due to the fact that tangential projections which are necessary for its detection were available in only half of the cases Indentation is an important sign in broad based polyps (WELIN 1967) and almost pathognomonic of infiltrative growth (WELIN 1971) But the absence of indentation does not exclude the possibility of malignant degeneration It was observed in all but 5 cases at the last examination in the present series

FROM THE DEPARTMENT OF RADIOLOGICAL SCIENCES UCLA SCHOOL OF MEDICINE,
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CONCEPTUAL FRAMEWORK OF A COMPUTER BASED LIBRARY CIRCULATION SYSTEM FOR THE RADIOLOGY FILE ROOM

JAMES WINTER and MARK ALLEN STEIN

The growing size and complexity of many medical centers results in difficulty in locating patient information The breakdown of manual library circulation control has resulted in serious inefficiency in radiology film libraries in many hospitals The inability to locate the film jacket for review or comparison with current examinations is a problem of increasing concern to the radiologist Even temporary inability to locate films greatly impedes patient care and is extremely frustrating to all concerned Errors occur because films are lost when decisions must be made Unnecessary repetition of examinations occurs, with the attendant risk discomfort and expense A great deal of valuable physician time is wasted when retrieval is delayed These problems are aggravated by the difficulty encountered in obtaining competent and motivated medical library personnel Unfortunately these problems are often not given the attention they deserve due to failure to appreciate the magnitude of the problem (JYDSTRUP & GROSS 1966) or the severity of the consequences

Improved health care delivery would result from eliminating the file room circulation problem However a conceptual framework is needed before it

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wahrend einer durchschnittlichen Zeit on 5 Jah en vorgenommen worden Wenn um ersten mal nachgewiesen hatten alle ausser 4 der polypoiden Tumoren zu mindest ein mit enalog sches Zeichen on Malignitat Die durchschnittliche lineare Wachstumsge schwindigkeit im Diameter betrug 0 61 mm/Monat die 5 jahrige Überlebensfrequenz betru 57 Metasta en wurden n 19 Fallen gefunden

RÉSUMÉ

Les auteurs ont étud 30 malades traites pour cancer du colon et du rectum qui etait developpe comme on pu le montrer r trospectivement a partir d petites tumeurs pol po des Des examens radiographiques repetes en doubl contrast ont et faits avant l opera tion pendant un temps d observation moyen de 5 ans Quand elles ont et mises en evidenc pour la premiere fois toutes les tumeurs pol poides sauf quatre avaient a moins un gne radiographique d malignit Le taux moyen de croissanc lineaire de leur diametre etait de 0 61 mm par mois Le taux de survi à 5 ans etait d 57 Les auteurs ont trouv des metastases dans 19 cas

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number of jackets in circulation,
film jacket, and the frequency of
film jackets to leave the radiol
problem and is unacceptably rest
ing high quality rapidly produc
economically viable alternative at

The circulation problem is alr
and the medical record library (
and can be dealt with independe
nature of the volumes they cont
cepts or techniques to be presente
If this generality is recognized sy
shared among multiple users

Before the problem can be app
must be made explicit (WATKIN
comply with stringent rules which
time to carry films to a central loc
Therefore restrictions on circulat
jacket locations to be rapidly
should be eliminated when possible

A fixed loan period is desirable
of the attributes of the film jacke
renewals ensure that the borrower ... and needs the film jacket Incentives may be fines suspension of borrowing privileges, or other means, but should be effective in promoting prompt return or renewal and in discouraging loss Removal of film jackets from the radiologic department without notifying the circulation system constitutes theft just as it would in the public library Severe sanctions should be imposed to discourage this Failure to identify and promptly retrieve overdue and stolen film jackets until the time of the next request is a major cause of loss of control

The objective of a circulation system (locator) is to provide current knowledge of film jacket locations while allowing complete freedom to obtain and relocate them This is achieved by requiring that the locator be notified of each and every relocation of a film jacket This requirements is realistic if the notification procedure is simple and the locator is readily accessible The notification procedure is the same regardless of the nature of the relocation Transferring film jackets between doctors between doctors and file rooms and between file room film bins involves identical procedures

Equivalence of relocation procedures is possible because both people and places may act as borrowers Placing a film jacket in a file room bin is analogous to

tempting a solution This communication sets forth the underlying concepts for efficient radiology film library circulation control

Manual circulation control

Circulation control is built upon a charging system which records pertinent information regarding loans These systems generally include provisions for handling reserve requests and recalling overdue material

Radiology film and medical record libraries differ from most public and private libraries (a) activities occur at an accelerated pace (b) circulating volumes must be immediately traceable (c) shelving arrangement is usually based on accession number (the hospital number) rather than on subject classification (d) a closed stack policy is usually adopted allowing only file room personnel to shelve and unshelve volumes, (e) loans occur between borrowers outside the library and (f) volumes are created destroyed and combined upon demand

A review of the charging systems used in public (FRY et coll 1961 GEER 1955 HOOG et coll 1961) and medical school libraries (BALKEMA 1966) shows that many of the systems commonly in use suffer from a number of shortcomings The most efficient techniques employ photographic or other mechanical methods to record circulation information These techniques are awkward in dealing with reserve requests and fail to provide a mechanism for readily locating a particular circulating volume because they record loans in the order that they occur Only the tedious and less efficient manual methods deal satisfactorily with these problems (FRY et coll) These offer drawbacks in the form of increased labour and chance for error in manual transcription of information A communication technique to allow easy and accurate borrowing of volumes from remote locations is not available with conventional circulation methods

There has recently been considerable interest in library automation Computer based circulation systems are being developed for public and university libraries (CHAPMAN et coll 1970 HAYES & BECKER 1970) as well as for medical school libraries (PAYNE et coll 1966 PIZER et coll 1964) in an attempt to overcome the limitations of manual systems However these endeavours have not been focused on the radiology film library

Concepts for designing automated locator systems

The problem is the inability to locate roentgen film jackets The most recent examinations are the most active, most frequently requested and most difficult to find The magnitude of the file room problem depends largely upon the

Table

The structure of information that a locator must retain. Interrelationships among the entries demonstrate the application of the concepts

Volume		Borrower		Date	Status
Type	Identification	Type	Identification	(Time)	
Film jacket	042 75 10 4	Clinic	Orthopedics	8/7	Due
Film jacket	047 21 95 2	Doctor	R. M. Williams	9/6	Due
Film jacket	047 21 9 3	Operation theatre	No. 3	8/8	Due
Medical chart	04 21 9 3	Doctor	S. J. Jones	8/5	Due
Film jacket	047 1 95 3	Room	Rig demonstration No. 2	8/8	Overdue
Film jacket	017 51 80 7	Film bin	Medical No. 7	8/6	Due

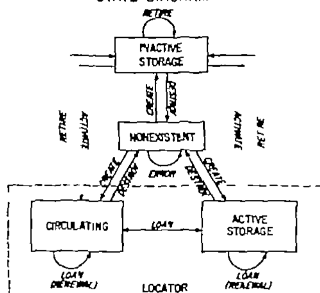
These labels may or may not be numerically related to the hospital number and are reassignable. Uniqueness and reassignability eliminate the multiple film jacket ambiguity and the need to maintain a record of all film jackets belonging to each patient, respectively.

Film jackets may be regarded as being in one of four possible states determined by the borrower to which they are assigned: (a) circulation outside the library, (b) active storage in the library, (c) inactive storage in the library, and (d) non-existent. A circulation system must retain the current locations of circulating and active film jackets only. The types of relocations and their effects on the states of the film jackets are summarized in the Figure.

The borrower possessing the largest number of film jackets is the inactive storage area(s). It is the only borrower that need not be identified by a circulation system. Therefore, any film jacket with an unspecified location is either in inactive storage or non-existent. This greatly reduces the amount of information a locator must retain and is feasible because relocation of inactive film jackets is infrequent. An inventory of film jacket locations in all states may be provided as a by-product. The inventory includes the locations of inactive film jackets even if multiple inactive storage areas exist. This resolves the ambiguity between inactive and non-existent film jackets as well as providing the actual number of film jackets existing and destroyed for each patient.

Due dates are computed upon relocations and must be retained for all active and circulating film jackets. Renewals are simply relocations to the same borrower resulting in a new date. Because of the borrower equivalence concept, film jackets in file room bins also have due dates; the need to retire these jackets because of inactivity is apparent when they become overdue.

STATE DIAGRAM



An identical procedure may be used to notify the circulation system of all of these relocations. However only locations of film jackets in circulation and active storage need be retained by locator. Movement of film jackets to inactive storage or to the nonexistent state may be noted but need not be retained.

lending it to an individual. The need to find film jackets within the radiologic department and its file and film demonstration rooms as well as when lent to individuals underlies the equivalence of borrowers.

Borrowers may be identified by specifying the borrower type, e.g., physician, and the borrower identification, e.g., John Smith. It should be the responsibility of the borrower, not the lender, to notify the circulation system of a loan because the borrower is better able to identify himself and assume responsibility.

Each film jacket may be uniquely identified by specifying the volume type, e.g., film jacket, and the volume identification. The latter is related to the hospital number of a patient. In the simplest case, the volume identification is the hospital number. However, when multiple film jackets exist for a given patient, use of the hospital number alone fails to identify which film jacket is being referenced.

This ambiguity can be avoided if each film jacket is assigned a number unique among that patient's film jackets. The hospital number plus the assigned number then uniquely identify any film jacket. This method is only feasible if all previously assigned numbers for a given hospital number are known at the time the next number must be assigned (next film jacket is created) for that patient.

Since this is frequently not the case in radiology, a better technique for avoiding this ambiguity is to maintain a set of unique labels to be used as volume identifiers and to assign one of these to each film jacket that will be referenced

RÉSUMÉ

L impossibilite de retrouver les pochettes de films radiologiques est couteuse et prejudiciable aux soins des malades dans de nombreux hopitaux L inadaptation des techniques manuelles pour regler leur circulation motive la mise au point de concepts necessaires pour la creation d systemes automatiques d recherche Les auteurs ont construit un modele d remise en place des pochettes de films Les auteurs ont degage les concepts qui sont a la base de l identification des pochettes de films et des emprunteurs et a la base d choix des regles et des techniques de circulation dans les bibliotheques

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Reserve requests indicate a desired rather than an accomplished relocation. Therefore the reserve is like a relocation except that the desired rather than the due date is specified.

The information maintained in a circulation system (Table) must be available upon request. Overdue and reserve lists must be supplied at appropriate times. These should be listed according to borrower and shelving arrangement, respectively, to optimize the efficiency of file room personnel.

Conclusions

Current manual techniques of circulation control fail to adequately locate film jackets, especially in the teaching hospital setting. This results in poor health care delivery and is expensive, time consuming and frustrating. Concepts underlying a general solution to the circulation control problem are presented as a foundation for anyone designing a computer based locator system: (a) a minimum set of library rules sufficient to provide knowledge of film jacket locations, (b) use of identical procedures for communicating film jacket relocations to a locator system based upon identical treatment of all borrowers, (c) a technique for overcoming the problem of ambiguity in identifying multiple film jackets belonging to the same patient, (d) minimizing the information retained by a locator system without compromising knowledge of film jacket locations, (e) methods for handling reserve requests, for detecting and recovering overdue and lost film jackets, for purging inactive film jackets and for maintaining an inventory.

SUMMARY

The inability to locate roentgen film jackets is expensive and degrades patient care in many hospitals. Inadequacy of manual techniques for controlling circulation motivates the development of concepts needed for designing automated locator systems. A model of film jacket relocations is constructed. Concepts underlying the identification of film jackets and borrowers and the selection of library circulation rules and procedures are elucidated.

ZUSAMMENFASSUNG

Die Unmöglichkeit, Röntgenfilm-Umschläge zu lokalisieren, ist teuer und setzt die Patientenversorgung in vielen Krankenhäusern herab. Die Unzulänglichkeit einer manuellen Technik, um die Zirkulation zu kontrollieren, motiviert die Entwicklung von Begriffen, die gebraucht werden, um ein automatisches Lokalisationssystem zu entwerfen. Ein Modell zu Relokalisation von Filmumschlägen ist konstruiert. Die zugrundeliegenden Begriffe zu Identifikation der Filmumschläge und Entleiher und die Auswahl von Bibliotheks-Zirkulations-Regeln und die Handlungsweise werden dargelegt.

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